Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2013

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2015

Canadian Data Report of Hydrography and Ocean Sciences 198

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Canadian Data Report of Hydrography and Ocean Sciences

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Canadian Data Report of
Hydrography and Ocean Sciences 198

2015

PHYSICAL, CHEMICAL AND BIOLOGICAL OCEANOGRAPHIC DATA FROM THE BEAUFORT REGIONAL ENVIRONMENTAL ASSESSMENT: MARINE FISHES PROJECT, AUGUST-SEPTEMBER 2013

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Cat. No. Fs 97-16/198E ISBN 978-0-660-02948-1 ISSN 0711-6721 (print version)
Cat. No. Fs 97-16/198E-PDF ISBN 978-0-660-02949-8 ISSN 1488-5433 (online version)

Correct citation for this publication:

Niemi, A., Michel, C., Dempsey, M., Eert, J., Reist, J., Williams, W.J. 2015. Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2013. Can. Data Rep. Hydrogr. Ocean Sci. 198: vii + 144 p.

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ABSTRACT

Niemi, A., Michel, C., Dempsey, M., Eert, J., Reist, J., Williams, W.J. 2015. Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2013. Can. Data Rep. Hydrogr. Ocean Sci. 198: vii + 144 p.

Oceanographic and biochemical sampling was conducted as part of the Beaufort Regional Environmental Assessment (BREA) Marine Fishes project in 2013, providing baseline data for fish habitat, ecosystem linkages and food web interactions in the regional context of the Beaufort Sea. CTD (Conductivity Temperature Depth)/Rosette sampling was conducted at 55 stations along nine main transects on the Mackenzie shelf and slope and in the Amundsen Gulf. Station depths reached 1034 m on the Mackenzie slope and 510 m in the Amundsen Gulf. Sampling was conducted between 1 August and 11 September 2013. For each CTD/Rosette cast, vertical profile plots of CTD data are presented including temperature, salinity, transmissivity, fluorescence, dissolved oxygen, photosynthetically active radiation and turbidity. Vertical profile plots are also presented for the discrete rosette sampling of inorganic nutrients (NO_3 + NO_2, PO_4, $Si(OH)_4$), oxygen isotope ratio ($\delta^{18}O$), total and size-fractioned (5 µm) chlorophyll *a* and dissolved organic carbon. The report provides a comprehensive presentation of key physical and biochemical oceanographic variables, in near and offshore regions, to support ecosystem assessments and decision making processes for oil and gas activity in the Beaufort Sea.

RÉSUMÉ

Niemi, A., Michel, C., Dempsey, M., Eert, J., Reist, J., Williams, W.J. 2015. Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2013. Can. Data Rep. Hydrogr. Ocean Sci. 198: vii + 144 p.

Un échantillonnage océanographique et biochimique a été réalisé dans le cadre du projet des poissons marins de l'évaluation environnementale régionale de Beaufort (EERB) en 2013 et a permis de recueillir des données de référence pour l'habitat du poisson, les liens écosystémiques et les interactions dans le réseau trophique dans le contexte régional de la mer de Beaufort. On a procédé à un échantillonnage au moyen de la rosette CTP (conductivité, température et profondeur) à 55 stations le long des neuf transects principaux sur le plateau de Mackenzie et de la pente continentale et dans le golfe d'Amundsen. La profondeur de la station atteignait 1 034 mètres sur le plateau de Mackenzie et 510 mètres dans le golfe d'Amundsen. Les activités d'échantillonnage ont été effectuées entre le 1er août et le 11 septembre 2013. Pour chaque rosette CTP, des tracés de profil vertical des données de CTP sont présentés, notamment la température, la salinité, la transmissivité, la fluorescence, l'oxygène dissous, le rayonnement photosynthétiquement actif et la turbidité. Des tracés de profil vertical sont également présentés pour l'échantillonnage de rosette discret de nutriments inorganiques (NO_3 + NO_2, PO_4, $Si(OH)_4$), le ratio des isotopes de l'oxygène ($\delta^{18}O$), la biomasse totale et la mesure des concentrations de chlorophylle *a* (5 µm) et du carbone organique dissous. Le rapport présente en détail les principales variables océanographiques physiques et biochimiques, dans les régions côtières et extracôtières, pour appuyer les évaluations des écosystèmes et la prise de décisions concernant les activités pétrolières et gazières dans la mer de Beaufort.

ACKNOWLEDGEMENTS

We sincerely thank the captain and crew of the F/V *Frosti* for their excellent support throughout the cruise. Additionally, the management and staff of Frosti Fishing Ltd. were very accommodating and offered great support for the science work. We thank the Inuvialuit Game Council for continuing to support the Marine Fishes project. We also appreciate the guidance and support of the chief scientists, Andrew Majewski and Robert Young (DFO) and all team members of the Marine Fishes project. Laboratory and/or report support was provided by Anke Reppchen, Jean-François Hélie and Line McLaughlin. We also thank Al Mucci for overseeing the $\delta^{18}O$ measurements and Tim Siferd and Jim Hamilton for constructive reviews of this report. Project funding was provided by the Beaufort Regional Environmental Assessment (Aboriginal Affairs and Northern Development Canada), Environmental Studies Research Fund (Natural Resources Canada), International Governance Strategy (Fisheries and Oceans Canada), Program of Energy Research and Development (PERD, Natural Resources Canada) and ArcticNet. Additional funding was provided to projects PIs by Fisheries and Oceans Canada.

1.0 INTRODUCTION

The main objective of the Beaufort Regional Environmental Assessment (BREA) was to build a knowledge base to inform decisions pertaining to oil and gas activity in the Beaufort Sea. The multi-stakeholder initiative supported regional environmental and socio-economic research beginning in 2011. Research conducted under the BREA contributes to regulatory decision making by stakeholders including government, Inuvialuit and industry.

This report presents results from a BREA project, delivered by Fisheries and Oceans Canada (DFO), which focused on Fishes, Habitats and Ecosystem linkages to Oil and Gas Development. The BREA Marine Fishes project was conducted in collaboration with co-management partners from the six communities within the Inuvialuit Settlement Region (ISR). The general scientific approach for the program was ratified with the Inuvialuit Game Council (IGC) through consultations over the winter of 2011/2012.

The Marine Fishes project aimed to provide a baseline for fish species, addressing key information gaps on deep-water fish communities in the Beaufort Sea. The project included the study of ecosystem linkages and the role of marine fishes in the wider Beaufort Sea ecosystem. The 2013 research expedition was the second and final year of data collection for the Marine Fishes project with both years contributing to the first systematic fish and ecosystem study at depths from 150 to 1000 m on the outer continental shelf and slope areas of the Beaufort Sea. The study also included shallower stations to provide a comprehensive assessment of populations, habitats and ecosystem linkages. Specific objectives for the Marine Fishes project were to:

- conduct a field survey of offshore areas to 1000 m depth to establish fish occurrence and community diversity, habitat associations, and food web/trophic couplings within and among offshore habitats,

- establish functional relationships within/among offshore and slope, shelf and coastal, benthic and pelagic sub-ecosystems, and

- establish regional contexts for future monitoring and assessments (e.g., hydrocarbon metabolites, mercury, species diversity, habitat usage).

The Marine Fishes project included collaborative work between DFO programs as well as University, Alaskan and ISR Community partners. In 2013, a comprehensive ecosystem assessment was conducted including benthic and pelagic fishes, hydroacoustics, zooplankton, sea sediments and benthic epifauna and infauna. This data report presents the oceanography and marine productivity components of the Marine Fishes project that were delivered by DFO research partners. The information herein is important for understanding fish habitat and enhancing our knowledge of ecosystem structure in the regional context of the Beaufort Sea. The data presented can be used to identify water masses and oceanographic conditions which define and affect marine habitat on small and large scales. The oceanography and primary productivity components of the project also provide the baseline for drivers of ecosystem linkages and food web interactions.

This data report provides a summary of science activities and data collected from CTD (Conductivity Temperature Depth) profiles and rosette deployments at each of the project sampling stations. The CTD profiles include temperature, salinity, dissolved oxygen (DO), transmissivity, turbidity, photosynthetically active radiation (PAR) and fluorescence. Discrete bottle sampling from the rosette provided data for salinity, nutrients including nitrate plus nitrite, silicate and phosphate, oxygen isotope ratio ($\delta^{18}O$), total and >5 µm chlorophyll *a* and dissolved organic carbon. Other oceanographic and marine productivity samples collected, but not included in this report, are barium, bacteria and protist counts, fatty acids and stable isotopes of particulate organic material, microbial DNA and phytoplankton taxonomy. Dissolved inorganic carbon was also sampled at select stations and will be reported separately.

1.1 Field Program

The 2013 Marine Fishes project was conducted between 1 August and 11 September 2013 onboard the *F/V Frosti*, a commercial stern trawler based in Richmond, BC. The study area included a portion of the Beaufort Sea Large Ocean Management Area (LOMA, Cobb et al. 2008), which contains the marine component of the ISR, and the study area extended into and across the Amundsen Gulf (Fig. 1). Offshore sampling and access to deep water stations on the eastern Beaufort Sea shelf and slope was hampered by the persistence of sea ice throughout much of the study period (Figs. 2 and 3). During leg 1 of the expedition, sea ice covered much of the shelf and extended into the mouth of Amundsen Gulf, including Franklin Bay (Figs. 2). Consequently sampling plans for the shelf and Banks Island area were refocused within the Amundsen Gulf area including Darnley Bay, the location of a proposed Marine Protected Area for the Arctic (DFO 2011). Sea ice had moved sufficiently offshore to allow for the sampling of transects on the western portion of the Mackenzie shelf (Figs. 1 and 3) during leg 2 of the expedition.

The Mackenzie portion of the study area is characterized by a shallow shelf, extending approximately 100 to 150 km offshore, and a relatively steep shelf break to depths of 1000 m. Beyond the shelf break, the sea floor continues to drop to depths over 3000 m in the Canada Basin. Sampling conducted on the western side of the shelf (A1, TBS, GRY, Fig. 1) was in the vicinity of the Mackenzie Trough, an area of intensified currents. The Mackenzie shelf/slope and Amundsen Gulf is separated by a deep trough between Banks Island and the continental mainland. The Amundsen Gulf is ca. 400 km long with relatively deep sides and depths reaching over 600 m. Capes on the southern side of the Gulf (e.g. Bathurst and Parry) are locations of frequent wind induced upwelling events (e.g. Williams and Carmack 2008).

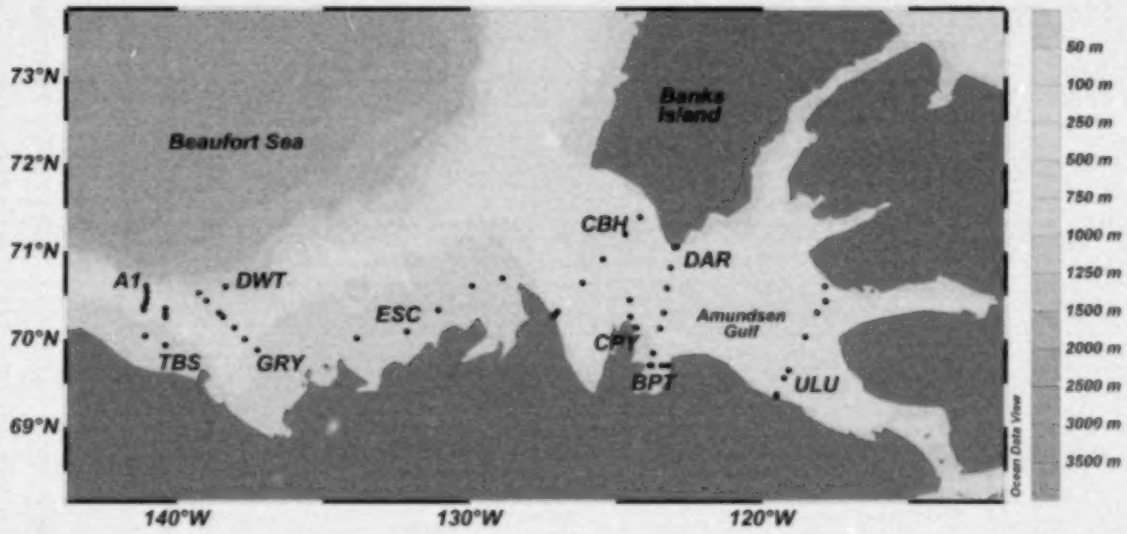
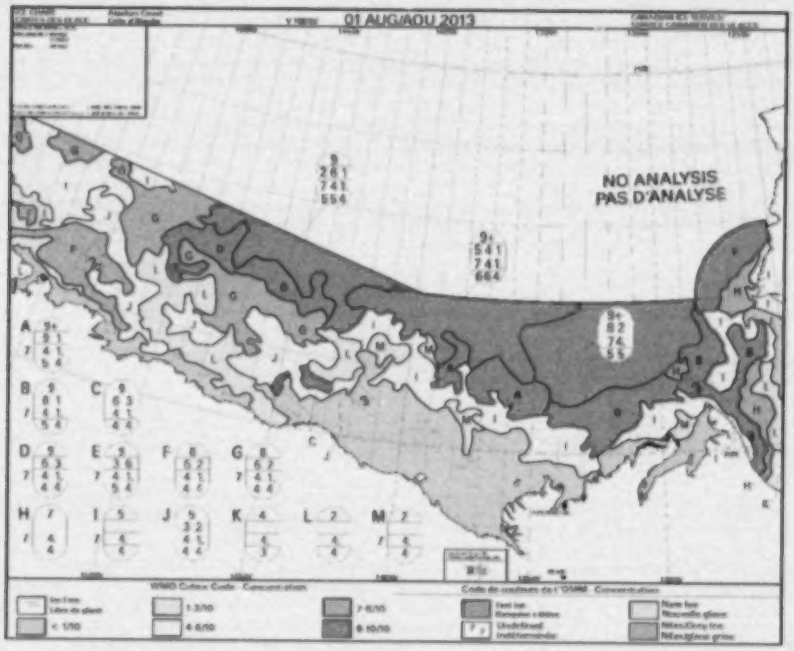


Figure 1. CTD/Rosette sampling stations of the BREA Marine Fishes project, 2013. Transect names are identified.

Six transects were visited within the Amundsen Gulf and near-shore along the Mackenzie Shelf during leg 1 of the expedition (2 to 27 August 2013). Transects CBH (7 stations), DAR (8 stations) and ULU (8 stations) extended north-south across the Amundsen Gulf near Cape Bathurst, Darnley Bay and the community of Ulukhaktok, respectively. The CPY transect (3 stations) extended offshore from Cape Parry and the BPT transect (5 stations) extended across Darnley Bay beginning at Bennett Point. The ESC transect (5 stations) ran along the 20 m isobath on the Mackenzie Shelf. The CTD/Rosette was deployed at all stations during leg 1 (Appendix 1) and the full suite of marine productivity samples were collected (Table 1). Station depth did not exceed 510 m during leg 1.

Three transects, GRY (7 stations), TBS (4 stations) and A1 (7 stations), were sampled during the second leg of the expedition (29 August-11 September 2013). The GRY transect repeated select stations sampled during BREA 2012 (Eert et al., 2015) and the transect was extended into deeper waters (i.e. >1000 m, Appendix 1). The TBS (trans-boundary) transect also repeated 2012 sampling stations. Transect A1 was completed for further trans-boundary comparisons with Alaskan research partners. Only discrete samples for salinity, $\delta^{18}O$ and nutrients were collected from the rosette at the GRY, TBS and A1 stations (Table 1). On September 9th the CTD/Rosette was also deployed at a single deep-water station (1015 m, DWT Fig. 1) with only a CTD profile taken (Appendix 3). Sea ice (Fig. 3) and weather conditions did not allow for further sampling of deep-water stations during leg 2.

A



B

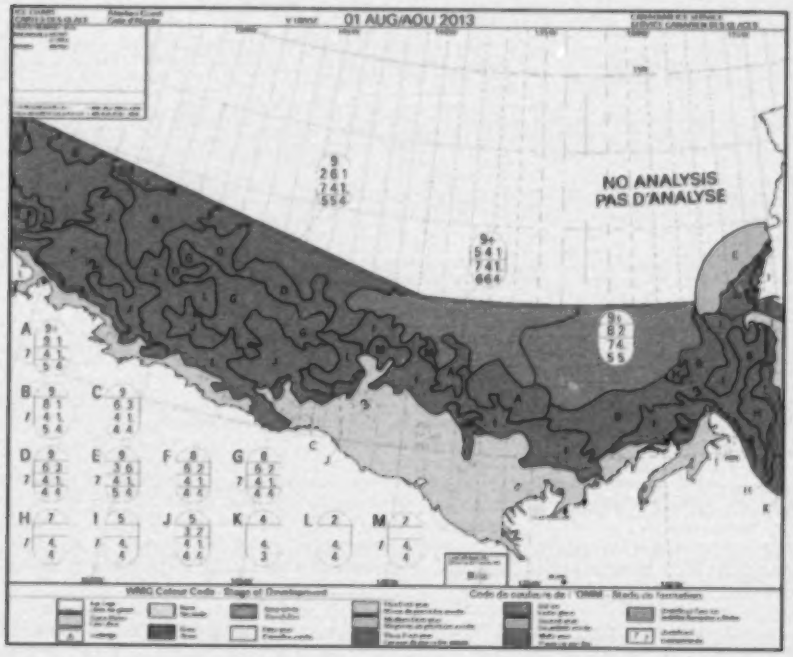


Figure 2. Study area sea-ice (A) concentration and (B) stage of development at the beginning of the BREA Marine Fishes expedition, 1 August 2013 (Canadian Ice Service).

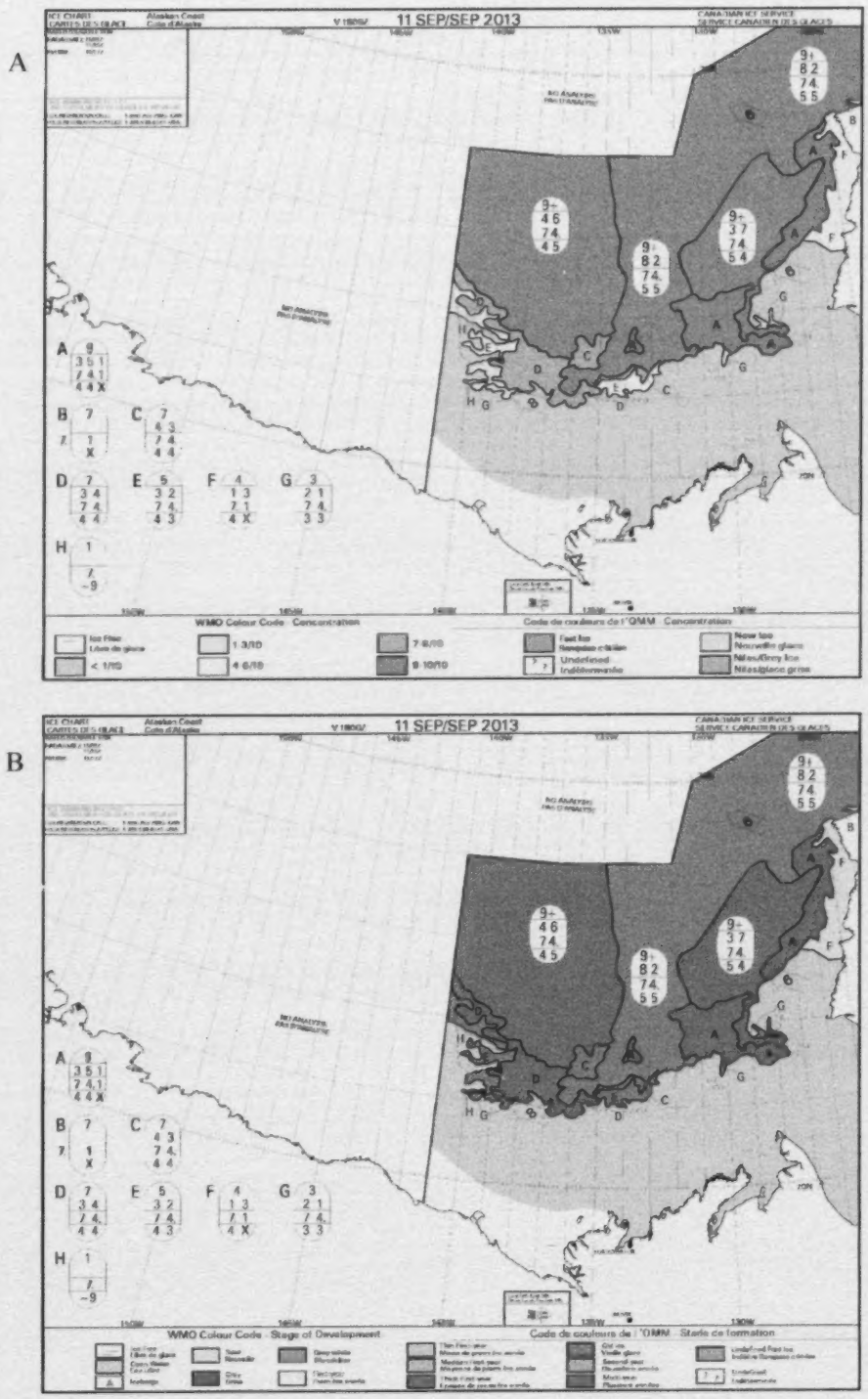


Figure 3. Study area sea-ice (A) concentration and (B) stage of development at the end of the BREA Marine Fishes expedition, 11 September 2013 (Canadian Ice Service).

2.0 METHODS AND ANALYSES

2.1 CTD/Rosette Casts

CTD profiles and water samples were collected with a 12-bottle rosette that included a Seabird SBE-25 and external sensors mounted within a stainless steel frame. A Benthos altimeter and Biospherical/LiCor underwater PAR sensors were mounted to the top of the rosette frame. The 12-8 L Ocean Test Niskin bottles were controlled by a SBE-32 carousel water sampler. Data signals from the SBE-25 were hardwired through a sea cable to the SBE-33 deck unit and Dell laptop located in the bridge for real-time telemetry and data acquisition.

The sensors used during each cast were:

- Seabird temperature 4444
- Seabird conductivity 3209
- Seabird pressure (strain gauge) 0603
- Seabird SBE-43 Dissolved Oxygen 1202
- Seapoint Fluorometer 2979 and 3575
- Wetlab CSTAR transmissometer CST-1047DR
- Seapoint turbidity meter (OBS) 11074
- Biospherical/LiCor PAR 20280
- Teledyne Benthos Altimeter 41098

Standard deployment was to start the CTD on deck and the acquisition of real-time data once in the water. In-air pressure was checked during CTD recovery. Once submerged (ca. 2 m depth) the CTD/Rosette was soaked for two minutes before lowering at approximately 0.8 m/s to ca. 5 m off the bottom. The ship drifted during casts resulting in several casts with outboard wire angles of 10-15 degrees. Under these conditions, the rosette was stopped more than 5 m off the bottom. Niskin bottles were closed on the up cast after a 30 s stop. Once onboard, the conductivity cell and dissolved oxygen sensor were rinsed with Milli-Q water and the cell left full. The conductivity cell was periodically cleaned with dilute Triton-X.

At leg 1 stations with water depths >80 m, two casts were needed to collect the required water samples. The first cast sampled the deepest depths, and provided a complete CTD profile for the station. The second cast obtained the remaining samples and a repeated CTD profile for the upper water column only. The time between the first and second cast was kept as short as possible. At stations with two casts, both CTD profiles are presented in Appendix 2 and the Niskin bottle data for leg 1 are presented as a combination of the two casts. A maximum of 12 Niskin bottles were used at each station during leg 2, therefore there is only one CTD profile per leg 2 cast (Appendix 3).

Samples for dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), nutrients, bacteria, salinity, barium and $\delta^{18}O$ were drawn directly from the Niskin bottle spigot. The rest of the water was transferred to acid washed carboys for the remaining analyses. There were a total of 53 CTD/Rosette casts and 450 Niskins collected during leg 1 and another 23 CTD/Rosette casts and 123 Niskins collected during leg 2. Discrete water samples were collected from the CTD/Rosette deployments at each station (n = 36) during leg 1 and at 14 of 19 stations during

leg 2. For the CTD/Rosette casts at stations GRY-02, GRY-04, GRY-06, A1-05 and DWT-01, water was not collected due to weather and logistical constraints.

2.2 Chemical and biological sampling

Discrete water samples were collected during leg 1 at target depths of 5, 10, 20, 30, 40, 50, 60, 70, 80, 100, 125, 200, 300 m and 5-10 m above the bottom. Depths corresponding to the maximum chlorophyll fluorescence (chl*a*max) and the 33.1 psu Pacific layer were identified from CTD profiles and sampled. The same range of depths was targeted during leg 2. However, a maximum of 12 depths were sampled at leg 2 stations including 500 m and ca. 10 m above the bottom at the deepest station (max 1023 m).

Salinity, nutrients and $\delta^{18}O$ samples were taken at all depths during leg 1 and 2 whereas DOC, chlorophyll *a* (chl *a*), flow cytometry, particulate organic matter constituents (carbon (POC), nitrogen (PON), isotopes ($\delta^{13}C$, $\delta^{15}N$) and fatty acids), microbial DNA and phytoplankton taxonomy samples were collected during leg 1 only, at select depths including the depths of chl*a*max and 33.1 salinity. Table 1 provides an overview of the rosette water sampling presented in this report.

2.2.1 Salinity

Glass salinity bottles (125 ml) and Teflon inserts were rinsed three times with sample prior to filling to shoulder height. Bottles were sealed with the insert, closed with a screw-on cap and then stored at ambient temperatures between 5°C and 20°C until analyzed.

Salinity samples were analyzed with a Guildline Autosalinometer 8400B, SN 68572 Ocean Scientific International, at the Institute of Ocean Sciences, Sidney. Salinometer data logger software was used to log the conductivity readings from the Guildline instrument and the software calculated the salinity values.

A calibration was conducted prior to each analysis session and IAPSO Standard Seawater (K_{15} Value = 0.99979, Batch# P153 March 8, 2014) was run before and after each analysis session. The salinometer remained stable and within Guildline specifications of 0.002 PSU throughout the analyses. Samples were analyzed in a 24°C bath in a temperature-controlled lab where ambient temperature ranged between 22.2 and 24.0°C, with a 1.3°C maximum difference observed during an analysis session.

Sample bottles were inverted and mixed prior to analysis. The instrument was flushed a minimum of three times with sample before readings began and a minimum of two readings were taken for each sample with each reading representing an average of five measurements taken over five seconds. The accuracy and resolution of the readings were <+/- 0.0001 and <0.00001 of the conductivity ratio, respectively.

For the last three stations of the expedition (A1-04, A1-06 and A1-07) the salinity samples were collected in 125 ml plastic bottles and sealed with parafilm. An inter-comparison (n = 5) was conducted with an average salinity value of 32.4525 and 32.4473 for samples in glass and plastic bottles, respectively.

Table 1. Range of target depths for reported rosette water samples collected during the BREA Marine Fishes project 2013. Laboratories where samples were analyzed include: Institute of Ocean Sciences (IOS), Maurice-Lamontagne Institute (MLI), Université du Québec à Montréal (UQAM) and the Freshwater Institute (FWI).

Parameter	Casts*	Depth range	Analyses
Salinity	All Leg 1 & 2	5 m to near bottom	Shore lab - IOS
Nutrients	All Leg 1 & 2	5 m to near bottom	Shore lab - MLI
$\delta^{18}O$	All Leg 1 & 2	5 m to near bottom	Shore lab - UQAM
Chlorophyll *a*	All Leg 1	0-100 m; 33.1 salinity; chl*a*max; bottom	Onboard
DOC	All Leg 1	5, 20, 40, 70, 100, 125 m; 33.1 salinity; chl*a*max; bottom	Shore lab - FWI

* Excludes leg 2 casts for stations GRY-02, GRY-04, GRY-06, A1-05 and DWT-01.

2.2.2 Nutrients

Sample tubes (15 ml acid-washed Falcon tubes) and lids were rinsed three times with sample and then filled. The samples were immediately frozen at -50°C and later stored at -80°C until analyzed. All nutrient samples were analyzed for nitrate plus nitrite ($NO_3 + NO_2$), phosphate (PO_4) and silicate ($Si(OH)_4$) using a Seal Analytical AutoAnalyzer 3, at the Maurice-Lamontagne Institute. Stock solutions were made using potassium nitrate, 99.99% (Sigma 204110), sodium nitrite, 99.99%, (Sigma 431605), potassium dihydrogen-phosphate, 99.99% (Sigma 229806) and sodium hexafluorosilicate, puriss >99% (Sigma 71596), for nitrate plus nitrite, phosphate and silicate, respectively. Each chemical was dried for 1 hour at 105°C and then diluted to make 1 L of the respective stock solution. 1 ml of chloroform was added to phosphate, nitrite and nitrate stocks. The solutions were kept in the dark at 4°C and were stable for 6 months.

Fresh working standards were prepared daily by diluting the stock solutions. Working standards were analyzed and compared with reference solutions provided by the National Research Council (MOOS-2) and by the Ricca Chemical Company (phosphorus standard 0.025 mg P/ml, silicate standard 1 mg SiO_2/ml, nitrogen standard as nitrite 250 µg N/ml and nitrate standard 226 mg N/ml). Saltwater was used for the preparation of standards and as rinsing water. Silicate concentrations were corrected for salinity according to standard protocols.

2.2.3 $\delta^{18}O$

Oxygen-18 samples were collected in 125 ml High-Density Polyethylene (HDPE) bottles at each station and depth. The bottles were rinsed three times prior to filling and the samples were stored at room temperature until analyzed.

Analyses were carried out at GEOTOP (UQAM) using the isotopic CO_2-H_2O equilibration method. A Micromass Isoprime™ isotope ratio mass spectrometer in dual inlet mode coupled to an Aquaprep™ system was used. Each sample analysis used 200 µl of water that was equilibrated at 40^0C for 7 hours. The isotopic values are expressed as the δ notation and reported in ‰ vs. VSMOW (Vienna-Standard Mean Ocean Water, Coplen, 2011). The $\delta^{18}O$ values were corrected with a calibration to three internal laboratory standards ($\delta^{18}O$= -6.71‰, -13.98‰ and -20.31‰), which were normalized against the VSMOW-SLAP (Standard Light Antarctic Precipitation) scale. The precision of the analyses was estimated at +/- 0.05‰ reproducibility and 0.24‰ repeatability.

2.2.4 DOC

Duplicate DOC samples were collected with a sterile 60 cc syringe. The syringe was rinsed three times with sample prior to filling. The sample was passed through a combusted (450°C for 24 h) 25 mm Whatman GF/F filter held in an acid washed sweenex filter holder. Each sample was acidified with 50% phosphoric acid (H_3PO_4) at a final concentration of ca. 0.05%.

The DOC sample bottles were 20 ml amber glass bottles that were thoroughly washed prior to use. The washing procedure involves soaking in 10% HCl for 12 -24 h, four subsequent rinses with ultrapure water, and a final rinse with ultrapure water directly from the ultrapure unit. The bottles are then dried at 60°C in a clean oven and combusted at 550°C for 8 h. After cooling, each bottle is closed with an acid washed Teflon-lined septa and cap.

All DOC samples were kept refrigerated (4°C) and in the dark until analyzed at the Marine Productivity Laboratory, Freshwater Institute. DOC was analyzed using a Shimadzu TOC-VCPH equipped with a Shimadzu ASI-V autosampler (Hedges et al., 1993; Knap et al., 1996). Due to the build-up of salt on the combustion tube during sample analyses, the combustion tube and catalyst were changed frequently (i.e. every 90-120 samples/standards) followed by multiple ultrapure water rinses and a calibration using a standard potassium hydrogen phthalate acid (KHP) solution. The calibration curve was prepared by programmed auto-dilution (20-166 mmol m^{-3}) using ultrapure water as the diluent. The range of calibration standards was selected to encompass expected DOC concentration in the samples For the BREA 2013 DOC dataset, 6.8% of samples were outside (i.e. higher) the calibration range. Standard error of the calibration standards averaged 1.6% (range: 0.4 to 7%) and the calibration curve R^2 was consistently >0.99.

The analyses were systematically checked against Deep Sargasso Sea Reference water (DSR, 41-44 mmol m^{-3} DOC) obtained from the Hansell's Certified Reference Materials (CRM) program, University of Miami (rsmas.miami.edu/groups/biogeochem/CRM.html, Dickson et al., 2007). The DSR samples averaged 42 mmol m^{-3} DOC (range: 38-44 mmol m^{-3} DOC, n = 75). Replicability of duplicate DOC samples averaged 1.05% (range: 0.03-4.0%, n = 383).

2.2.5 Chlorophyll *a*

Chlorophyll *a* (chl *a*) concentrations were determined fluorometrically on fresh pigments extracted in 90% acetone according to Parsons et al. (1984), as detailed below. All chl *a* samples were analyzed onboard using a Turner Designs 10AU fluorometer calibrated using pure chl *a* extract (*Anacystis nidulans*, Sigma Chemicals). Fd and Tau values were 0.174 ($R^2 = 0.99$) and 1.953, respectively.

Duplicate chl *a* sub-samples were filtered onto Whatman 25 mm GF/F filters (nominal pore size of 0.7 µm) for the determination of total chl *a*, and onto 5 µm Nuclepore membrane filters to determine the > 5 µm chl *a* size fraction. Pigments were extracted in 10 ml of 90% acetone for 24 h at 4°C in the dark. After 24 h, the samples were allowed to warm to room temperature prior to taking fluorometric readings.

3.0 DATA

Individual station plots are presented for leg 1 (Appendix 2) and leg 2 (Appendix 3) stations. CTD data, without accompanying discrete rosette sampling, are presented for stations GRY-02, GRY-04, GRY-06, A1-05 and DWT-01. The oceanography and marine productivity data are linked to fish habitat groups identified by the Marine Fishes project. The fish habitat group for each station is identified in Figure 4, and also in Appendix 1. The habitat groups for marine fish were defined by water depths on the shelf and slope. The four fish habitat categories identified for 2013 were near-shore shelf (<75 m), off-shore shelf (75-200 m), upper slope (>200-500 m), and lower slope (>500 m) (Fig. 4).

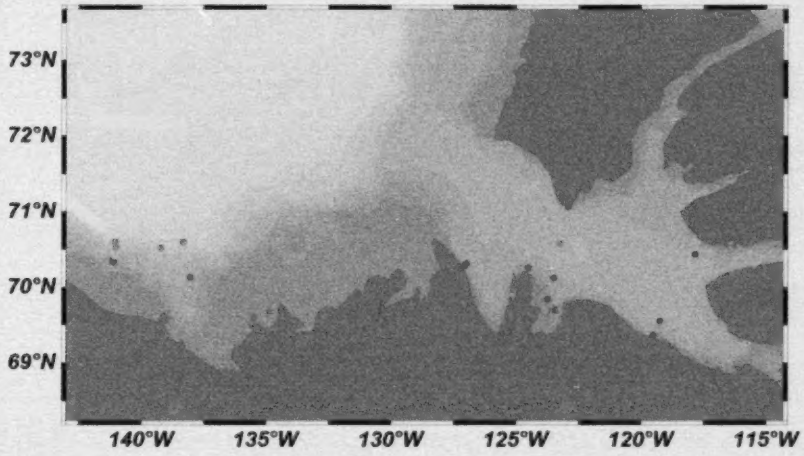


Figure 4. CTD/Rosette sampling stations corresponding to fish habitat groups on the shelf and slope of the study area. Fish habitat groups were identified as near-shore shelf (pink, <75 m), off-shore shelf (blue, 75-200 m), upper slope (green, >200-500 m) and lower slope (red, >500 m).

The CTD data shown in the station plots (Appendices 2 and 3) compare temperature, salinity, transmissivity, fluorescence, DO, PAR and turbidity. Bottle data for salinity and total chl *a* concentrations are overlain with the CTD salinity and fluorescence profiles, respectively, for comparison purposes. Station plots provided for the discrete rosette sampling compare profiles of the inorganic nutrients and total and 5 µm chl *a* and present $\delta^{18}O$ and DOC profiles separately. Salinity, $\delta^{18}O$ and nutrient data from the discrete rosette sampling are also presented in sections plots for the transects traversing Amundsen Gulf (i.e. CBH, DAR and ULU) and Darnley Bay (BPT, Appendices 4-7). Section plot data are presented for the upper 150 m only, focusing on the section of most intense sampling.

In 2013, surface waters showed evidence of recent ice melt due to the persistence of ice at the mouth of Amundsen Gulf and on the Mackenzie shelf. Nutrient concentrations were also generally higher relative to the 2012 Marine Fishes BREA expedition (Eert et al., 2015), likely due to mixing events related to ice and wind conditions at local and regions scales. For example, in February 2013 there was a large regional ice fracturing event (Fig. 5) that may have enhanced nutrient replenishment in surface waters during the winter period. Sea-ice conditions will need to be considered to explain inter-annual differences in marine ecosystem structure and linkages during the 2012-2013 BREA study periods.

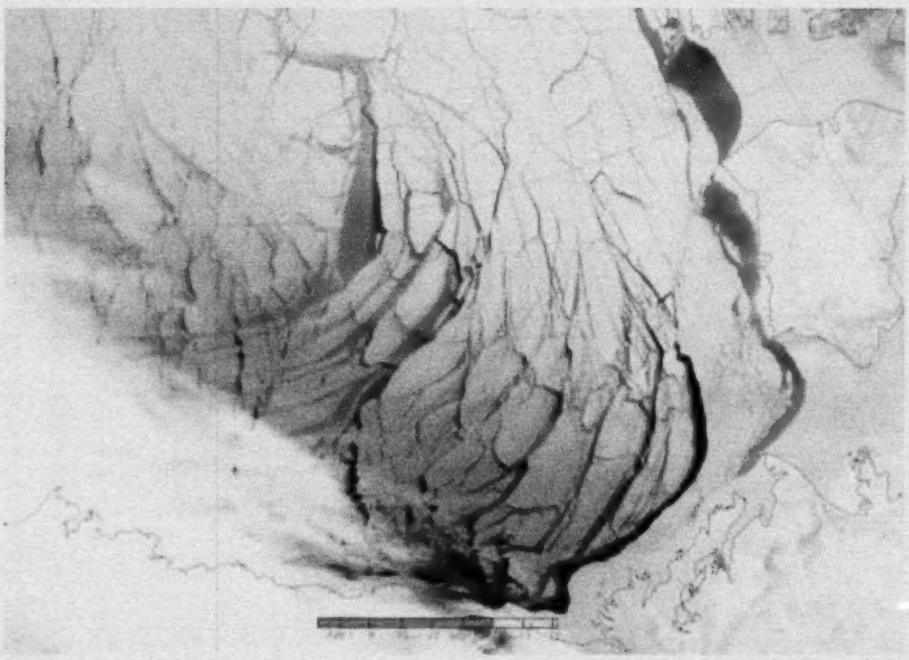


Figure 5. Wind induced sea-ice fracture extending across the Beaufort Sea in February 2013.

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Appendix 1. CTD/Rosette (ROS) deployment information for each sampling station during leg 1 and 2 of the BREA Marine Fishes project in 2013. Stations without water collection during leg 2 are indicated with an asterisk (*).

Cast	Cast Type	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (d/m/y; UTC)	Water Depth (m)	Habitat group
Leg 1									
1	ROS	CPY-01	70	13.44	124	29.99	02/08/2013 18:42	43	Near-shore shelf
2	ROS	CPY-02	70	15.57	124	30.46	03/08/2013 15:13	76	Off-shore Shelf
3	ROS	CPY-03	70	26.90	124	31.78	03/08/2013 20:57	226	Upper slope
4	ROS	CPY-03	70	26.84	124	30.68	03/08/2013 21:38	226	Upper slope
5	ROS	BPT-01	69	42.12	123	51.00	04/08/2013 16:06	25	Near-shore shelf
6	ROS	DAR-01	69	42.17	123	49.15	04/08/2013 19:53	32	Near-shore shelf
8	ROS	BPT-02	69	42.03	123	46.04	05/08/2013 15:45	76	Off-shore Shelf
9	ROS	BPT-03	69	41.93	123	26.27	06/08/2013 1:09	128	Off-shore Shelf
10	ROS	BPT-03	69	41.90	123	26.48	06/08/2013 1:30	127	Off-shore Shelf
11	ROS	BPT-04	69	41.84	123	14.41	06/08/2013 16:16	75	Near-shore shelf
12	ROS	BPT-05	69	41.95	123	11.73	06/08/2013 21:00	42	Near-shore shelf
13	ROS	DAR-02	69	50.42	123	43.67	07/08/2013 13:14	84	Off-shore Shelf
14	ROS	DAR-03	70	7.50	123	29.56	07/08/2013 19:20	195	Off-shore Shelf
15	ROS	DAR-03	70	7.59	123	29.50	07/08/2013 19:52	201	Off-shore Shelf
16	ROS	DAR-04	70	18.21	123	22.33	08/08/2013 13:09	342	Upper slope
17	ROS	DAR-04	70	18.37	123	22.14	08/08/2013 13:52	342	Upper slope
18	ROS	DAR-05	70	34.97	123	14.93	08/08/2013 21:41	505	Lower slope
19	ROS	DAR-05	70	35.01	123	14.54	08/08/2013 22:34	510	Lower slope
20	ROS	DAR-06	70	48.92	123	7.82	09/08/2013 17:28	363	Upper slope
21	ROS	DAR-06	70	48.89	123	8.13	09/08/2013 18:10	363	Upper slope
22	ROS	DAR-07	71	2.91	122	59.10	10/08/2013 13:09	207	Upper slope

Appendix 1 continued.

Cast	Cast Type	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (d/m/y; UTC)	Water Depth (m)	Habitat group
Leg 1									
23	ROS	DAR-07	71	2.91	122	59.13	10/08/2013 13:46	205	Upper slope
24	ROS	DAR-08	71	3.64	122	55.02	10/08/2013 17:48	82	Off-shore Shelf
25	ROS	ULU-01	69	20.81	119	30.83	13/08/2013 13:53	46	Near-shore shelf
26	ROS	ULU-02	69	22.34	119	30.27	13/08/2013 19:17	82	Off-shore Shelf
27	ROS	ULU-03	69	33.45	119	14.81	14/08/2013 13:08	195	Off-shore Shelf
28	ROS	ULU-03	69	33.80	119	14.07	14/08/2013 13:42	209	Off-shore Shelf
29	ROS	ULU-04	69	38.73	119	5.45	14/08/2013 19:11	351	Upper slope
30	ROS	ULU-04	69	38.52	119	5.86	14/08/2013 19:56	341	Upper slope
31	ROS	ULU-05	70	1.81	118	31.76	15/08/2013 13:39	447	Upper slope
32	ROS	ULU-05	70	1.81	118	31.55	15/08/2013 14:24	453	Upper slope
33	ROS	ULU-06	70	18.22	118	7.63	15/08/2013 20:59	352	Upper slope
34	ROS	ULU-06	70	18.09	118	7.76	15/08/2013 21:40	350	Upper slope
35	ROS	ULU-07	70	26.02	117	49.89	16/08/2013 15:22	79	Off-shore Shelf
36	ROS	ULU-08	70	36.09	117	51.30	16/08/2013 20:17	215	Upper slope
37	ROS	ULU-08	70	36.10	117	51.33	16/08/2013 20:45	202	Upper slope
38	ROS	CBH-01	70	16.10	127	6.18	20/08/2013 13:10	46	Near-shore shelf
39	ROS	CBH-02	70	17.15	127	4.19	20/08/2013 16:43	79	Off-shore Shelf
40	ROS	CBH-03	70	18.91	126	59.13	20/08/2013 20:17	205	Off-shore Shelf
41	ROS	CBH-03	70	18.88	126	59.73	20/08/2013 20:48	199	Off-shore Shelf
42	ROS	CBH-04	70	38.35	126	7.85	21/08/2013 13:59	286	Upper slope
43	ROS	CBH-04	70	38.32	126	7.75	21/08/2013 14:32	287	Upper slope
44	ROS	CBH-05	70	54.98	125	25.97	21/08/2013 21:25	349	Upper slope

Appendix 1 continued.

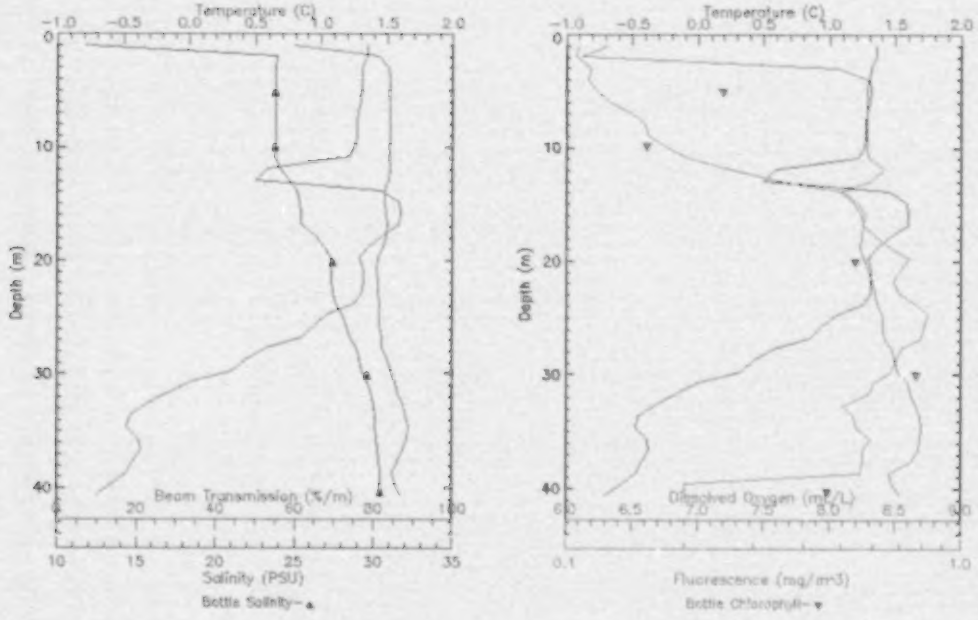
Cast	Cast Type	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (d/m/y; UTC)	Water Depth (m)	Habitat group
Leg 1									
45	ROS	CBH-05	70	55.02	125	26.06	21/08/2013 22:05	354	Upper slope
46	ROS	CBH-06	71	12.02	124	40.90	22/08/2013 13:30	275	Upper slope
47	ROS	CBH-06	71	12.03	124	40.75	22/08/2013 14:10	275	Upper slope
48	ROS	CBH-07	71	23.59	124	10.04	22/08/2013 20:52	202	Upper slope
49	ROS	CBH-07	71	23.60	124	10.02	22/08/2013 21:22	202	Upper slope
50	ROS	ESC-01	70	41.64	128	52.23	25/08/2013 13:09	22.8	Near-shore shelf
51	ROS	ESC-02	70	36.33	129	52.63	25/08/2013 21:36	22	Near-shore shelf
52	ROS	ESC-03	70	20.08	131	3.13	26/08/2013 13:01	23.5	Near-shore shelf
53	ROS	ESC-04	70	5.18	132	9.98	26/08/2013 18:59	24	Near-shore shelf
54	ROS	ESC-05	70	0.66	133	50.60	27/08/2013 13:29	24	Near-shore shelf
LEG 2									
55	ROS	GRY-01	69	52.51	137	14.52	29/08/2013 13:17	47	Near-shore shelf
56*	ROS	GRY-02	70	0.06	137	40.57	29/08/2013 16:12	77	Off-shore shelf
57	ROS	GRY-03	70	7.85	138	1.90	29/08/2013 18:52	204	Off-shore Shelf
58*	ROS	GRY-04	70	15.36	138	24.48	29/08/2013 21:17	355	Upper slope
59	ROS	GRY-05	70	18.13	138	32.72	30/08/2013 13:08	500	Upper slope
60*	ROS	GRY-06	70	26.49	138	58.99	30/08/2013 16:45	761	Lower slope
61	ROS	GRY-07	70	31.46	139	14.09	30/08/2013 23:57	1034	Lower slope
62	ROS	TBS-01	69	55.79	140	22.64	02/09/2013 13:15	41	Near-shore shelf
63	ROS	TBS-02	70	15.13	140	22.60	02/09/2013 16:43	71	Near-shore shelf
64	ROS	TBS-03	70	16.86	140	22.54	02/09/2013 19:56	203	Upper slope
65	ROS	TBS-04	70	20.85	140	23.03	02/09/2013 22:00	351	Upper slope
68	ROS	A1-01	70	2.27	141	4.59	05/09/2013 13:06	45	Near-shore shelf

Appendix 1 continued.

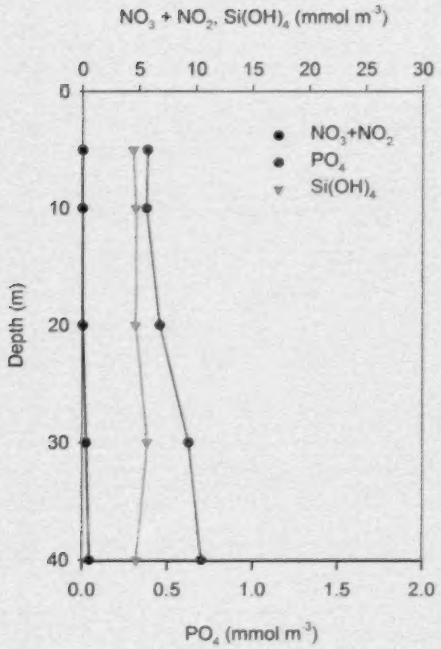
Cast	Cast Type	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (d/m/y; UTC)	Water Depth (m)	Habitat group
Leg 2									
69	ROS	A1-02	70	20.24	141	7.04	05/09/2013 16:14	80	Off-shore Shelf
70	ROS	A1-03	70	22.14	1441	7.79	05/09/2013 18:15	201	Off-shore Shelf
71	ROS	A1-04	70	24.73	141	3.39	05/09/2013 20:56	348	Upper slope
72*	ROS	A1-05	70	28.31	141	0.95	06/09/2013 00:08	505	Lower slope
73	ROS	A1-06	70	32.36	141	1.47	06/09/2013 13:06	757	Lower slope
74	ROS	A1-07	70	36.36	141	2.35	06/09/2013 17:30	998	Lower slope
76*	ROS	DWT-01	70	35.95	138	19.73	09/09/2013 13:24	1215	Lower slope

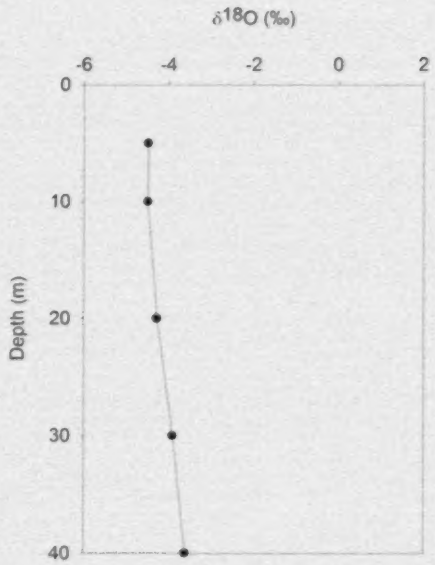
Appendix 2. CTD/Rosette station plots from leg 1 of the BREA Marine Fishes project, August 2013. Plots are identified by station name and sampling date, expedition cast number and fish habitat grouping. CTD plots (temperature, salinity, transmissivity, fluorescence, dissolved oxygen (DO), photosynthetically active radiation (PAR) and turbidity) are presented first, followed by the rosette plots (inorganic nutrients (NO_3 + NO_2, PO_4, $Si(OH)_4$), $\delta^{18}O$, chlorophyll *a* (chl *a* total (tot) and 5 µm) and dissolved organic carbon (DOC)) for each cast. Transect and cast details are provided in Figure 1 and Appendix 1.

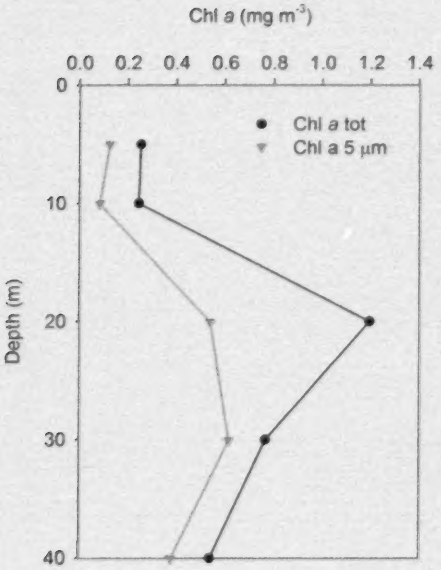
02/08/2013: Cast 1, Station CPY-01 (Near-shore shelf)

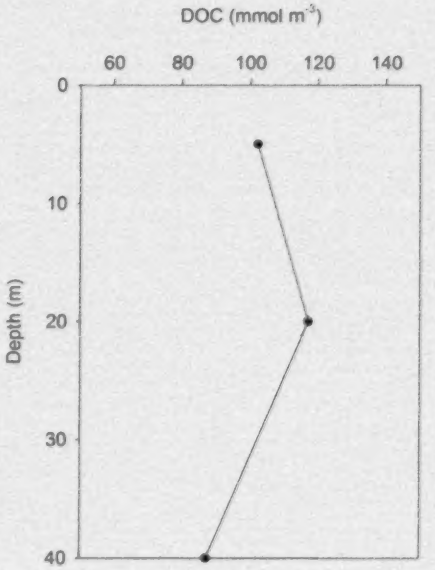


02/08/2013: Cast 1, Station CPY-01 (Near-shore shelf)

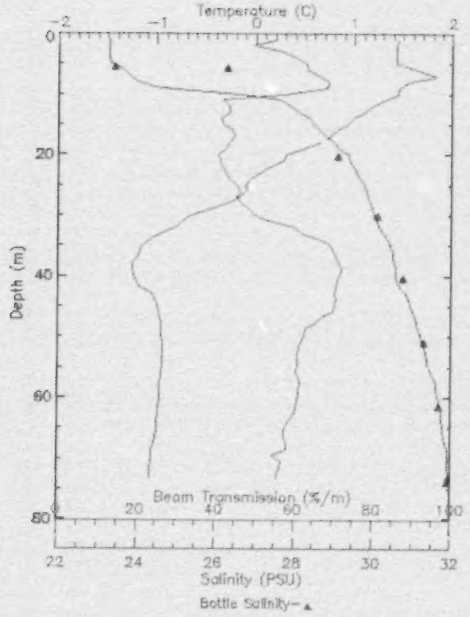


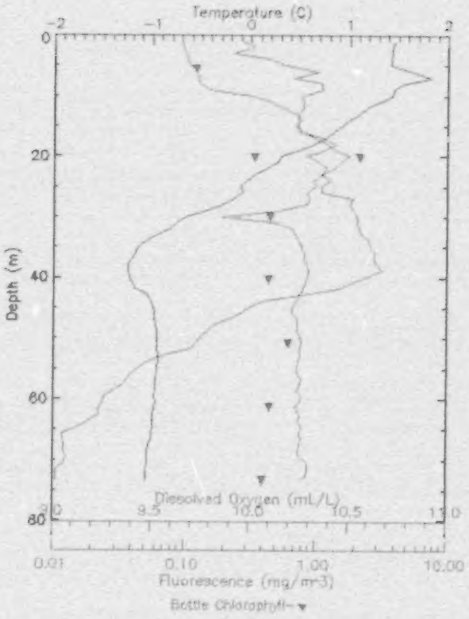


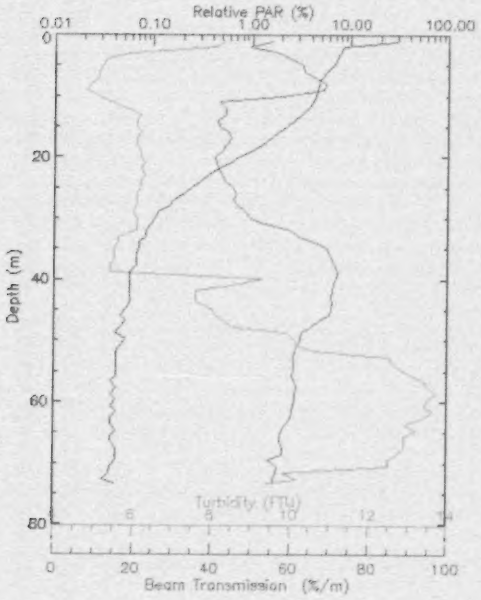




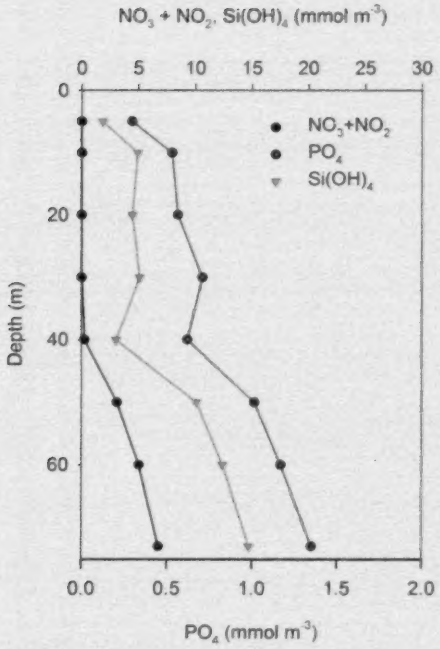
03/08/2013: Cast 2, Station CPY-02 (Off-shore shelf)

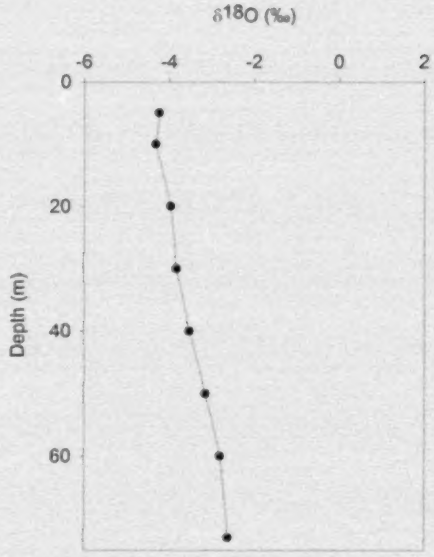


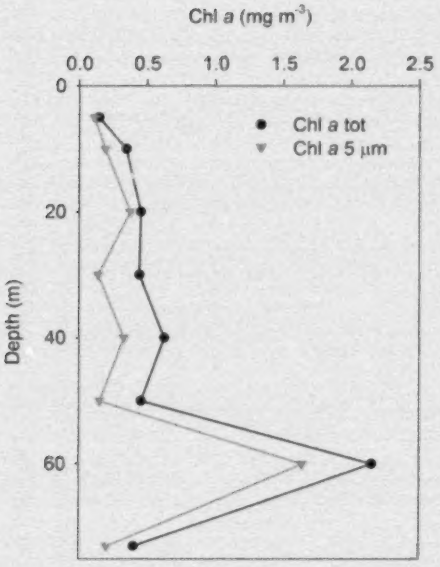


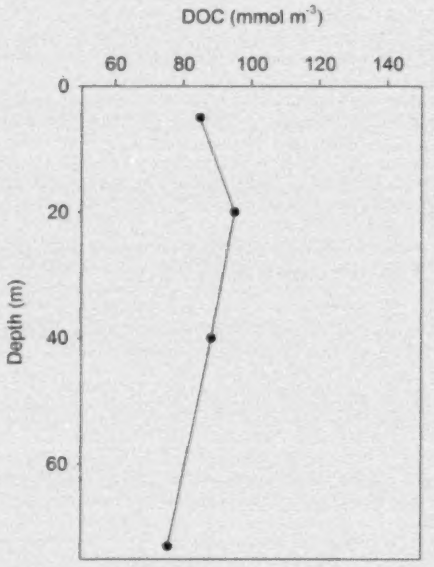


03/08/2013: Cast 2, Station CPY-02 (Off-shore shelf)

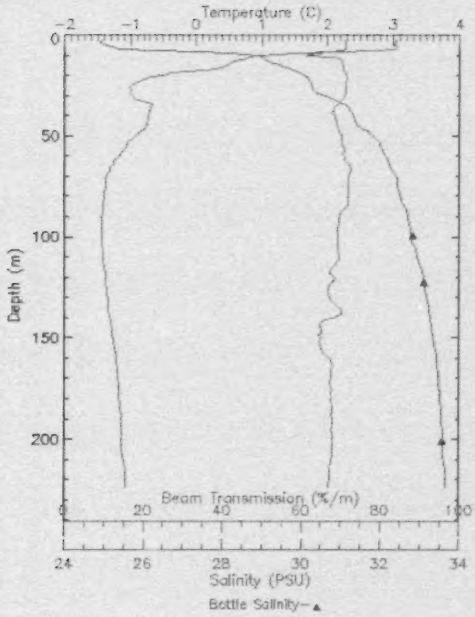


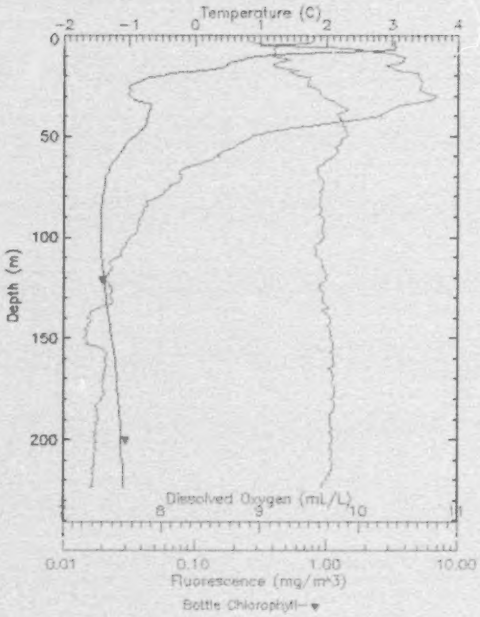


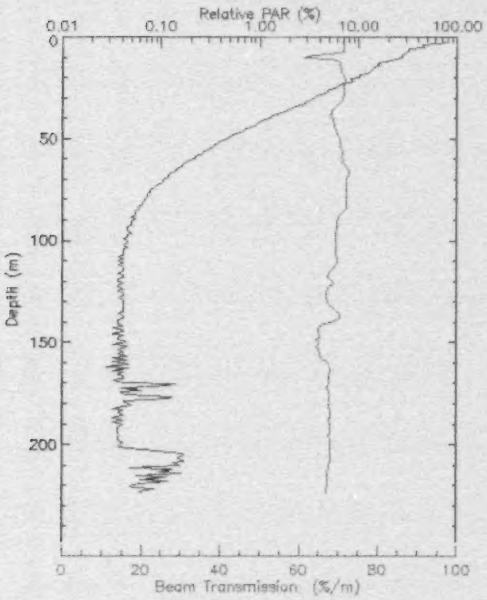




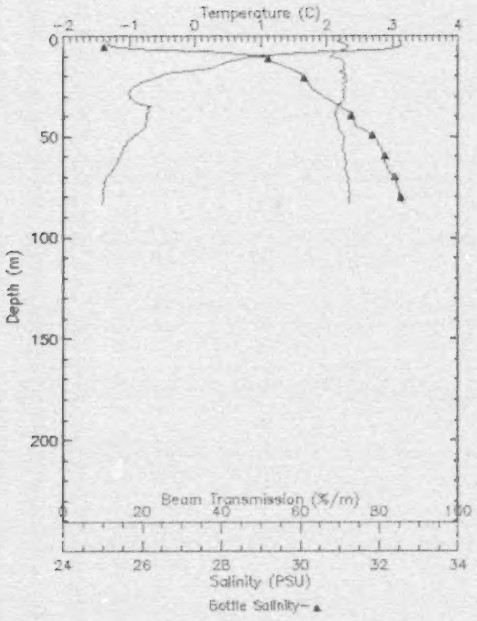
03/08/2013: Cast 3, Station CPY-03 (Upper slope)

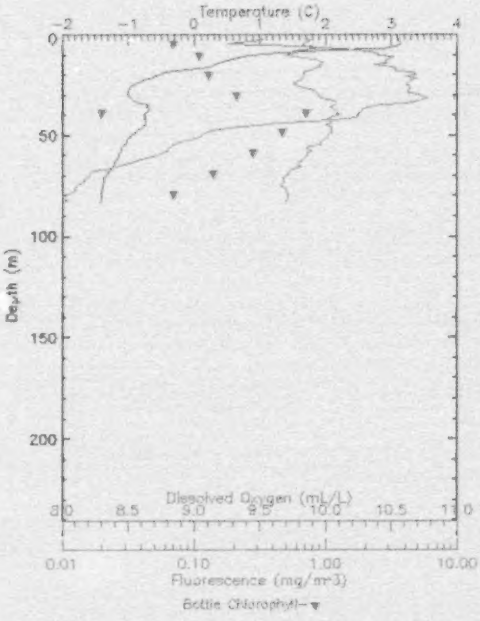


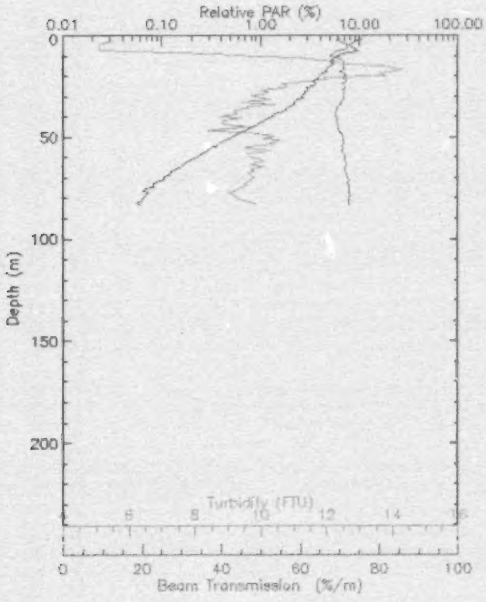




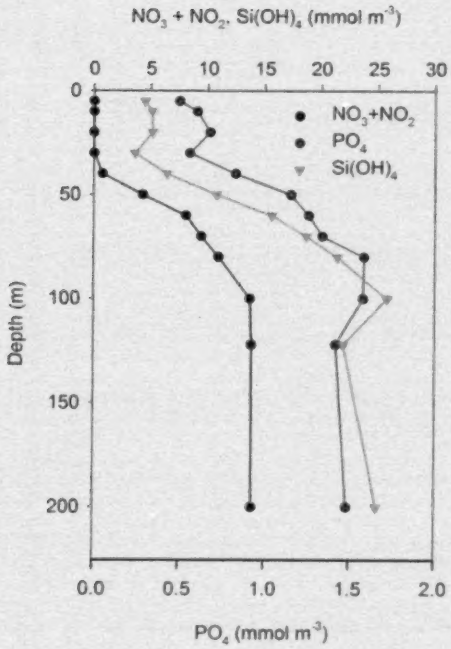
03/08/2013: Cast 4, Station CPY-03 (Upper slope)

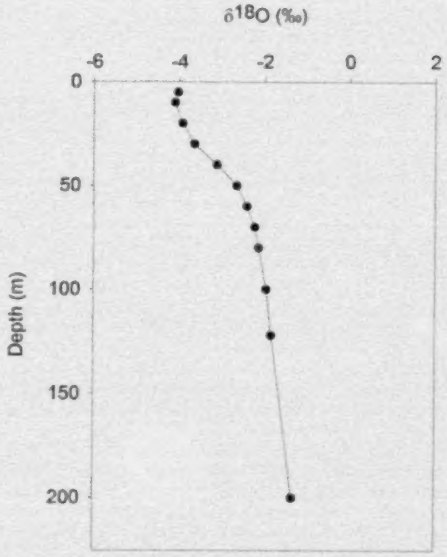


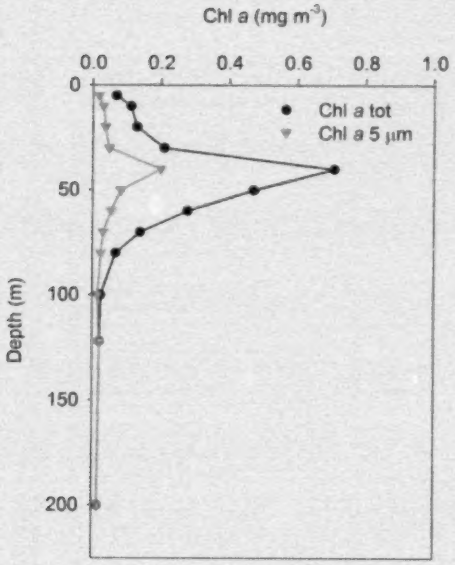


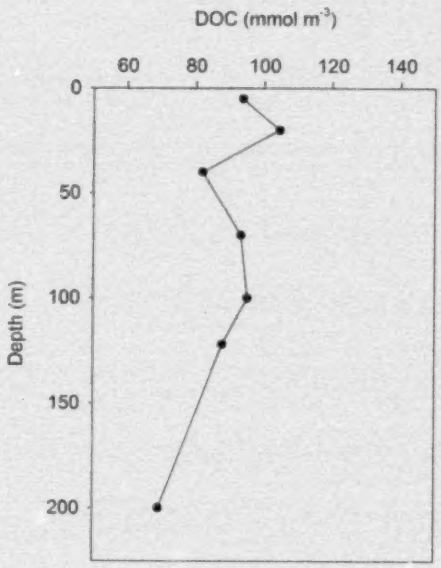


03/08/2013: Cast 3/4, Station CPY-03 (Upper slope)

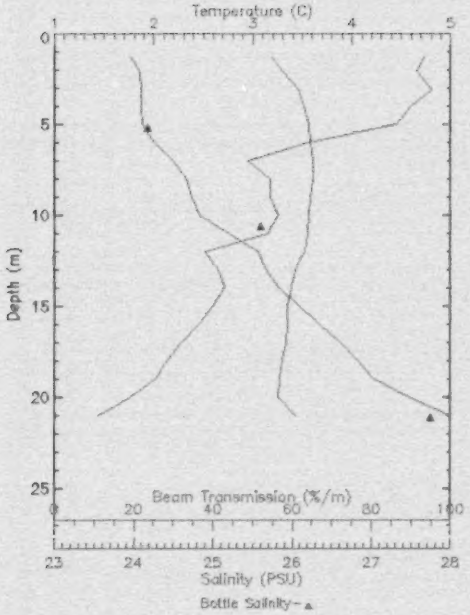


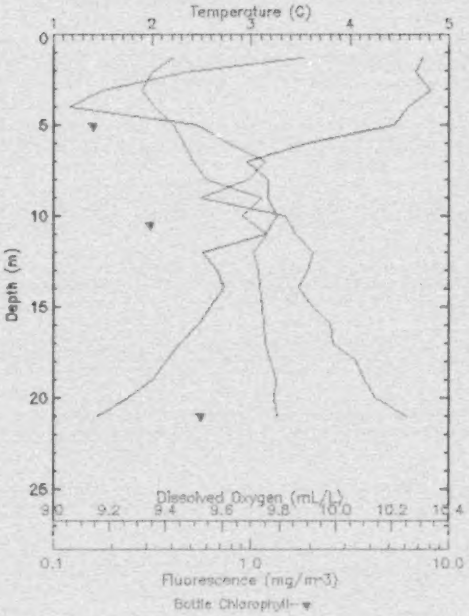


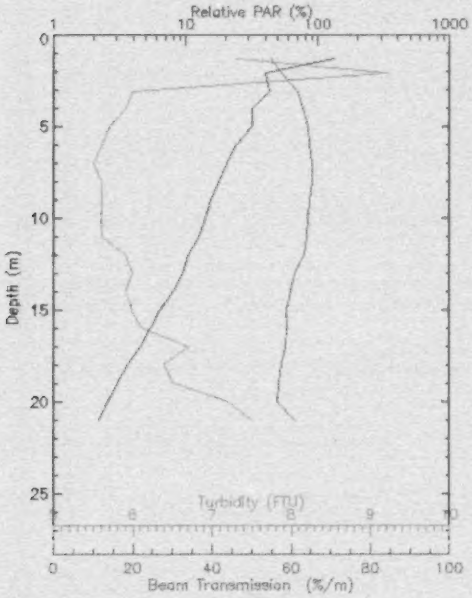




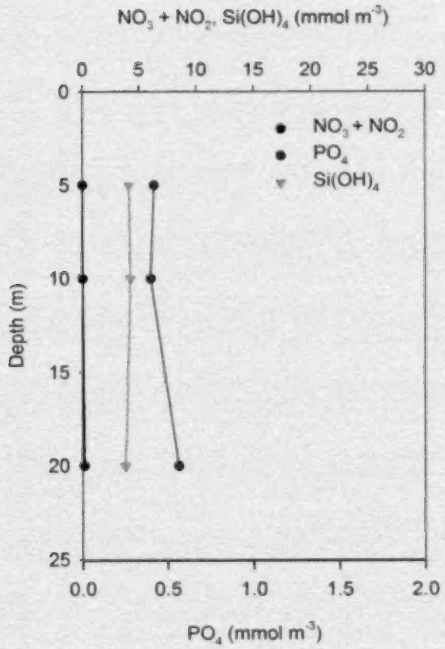
04/08/2013: Cast 5, Station BPT-01 (Near-shore shelf)

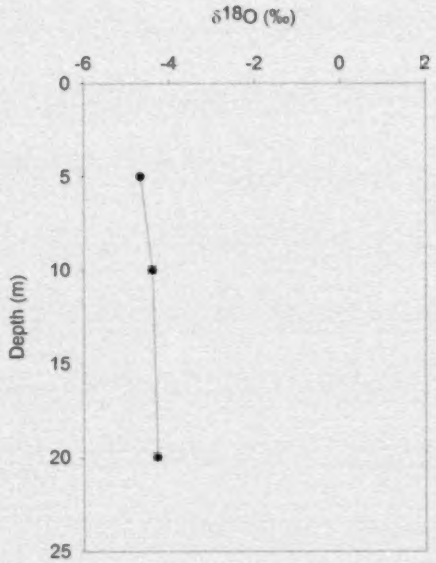


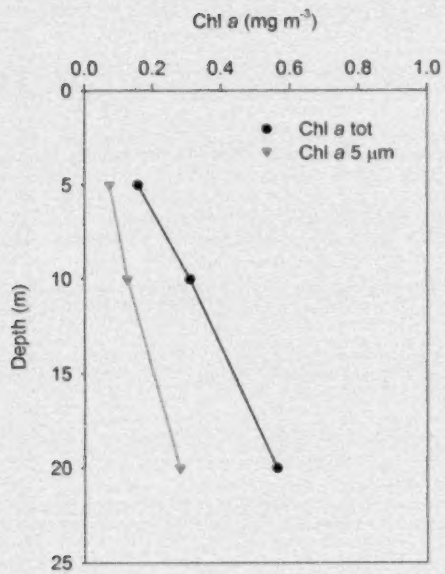


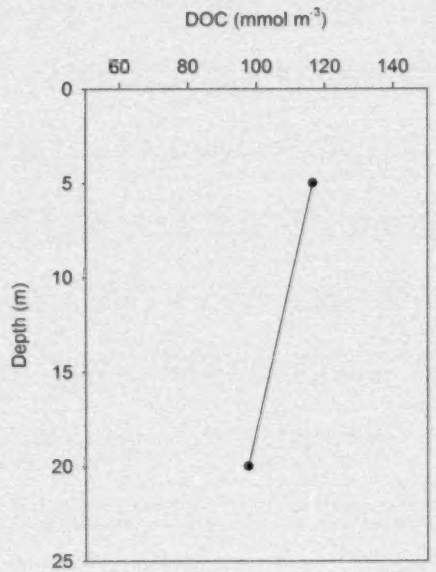


04/08/2013: Cast 5, Station BPT-01 (Near-shore shelf)

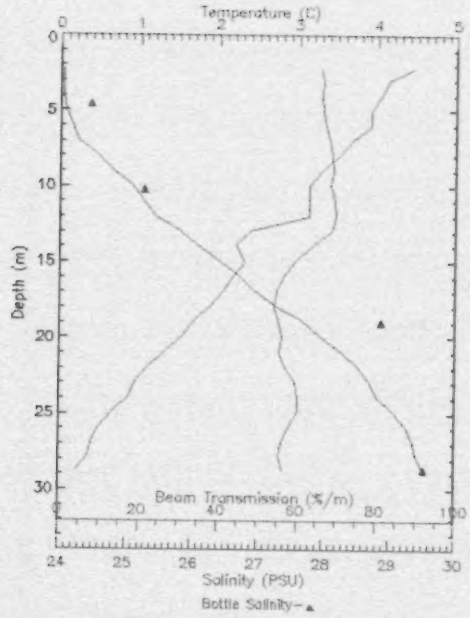


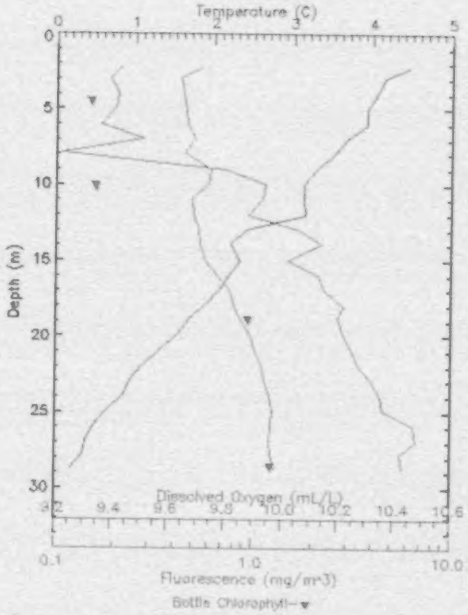


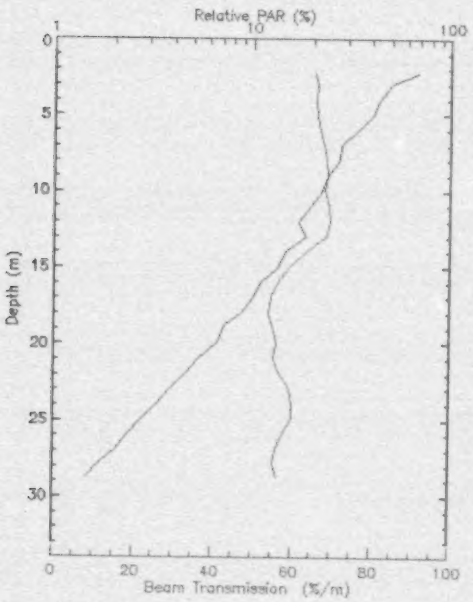




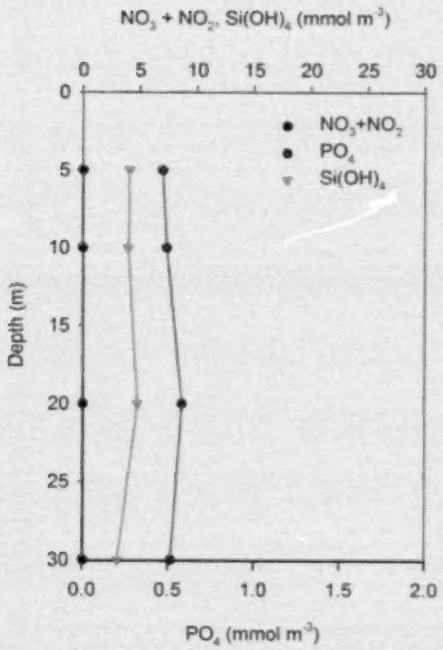
04/08/2013: Cast 6, Station DAR-01 (Near-shore shelf)

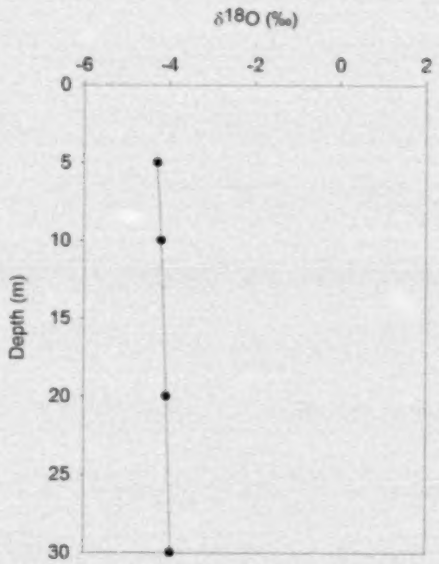


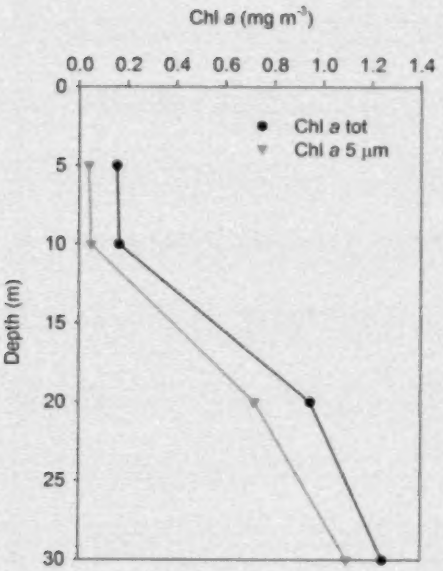


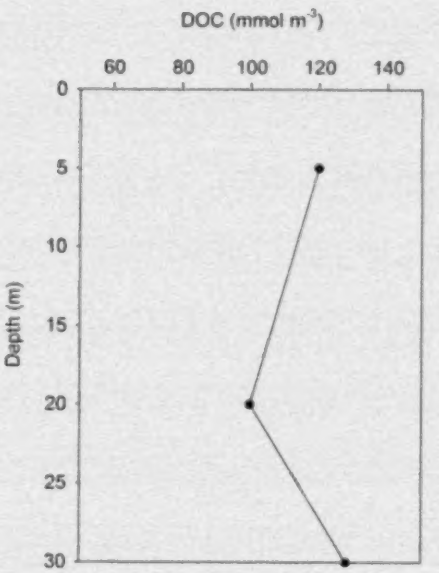


04/08/2013: Cast 6, Station DAR-01 (Near-shore shelf)

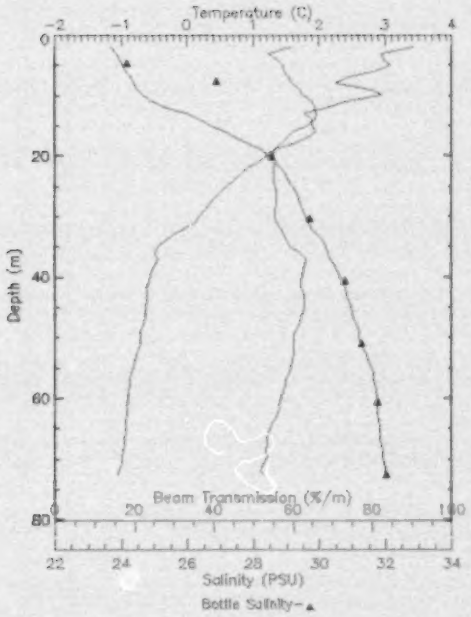


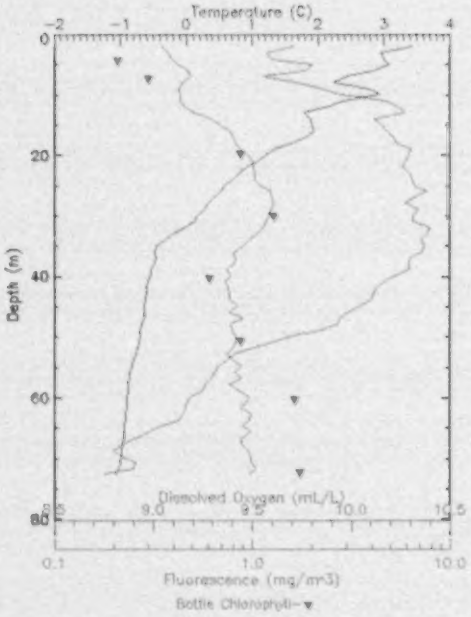


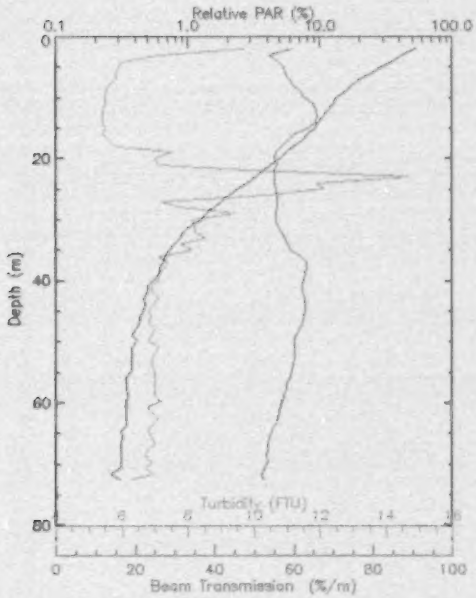




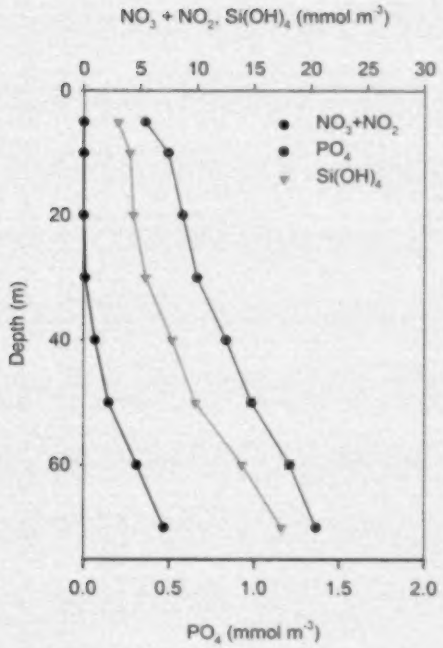
05/08/2013: Cast 8, Station BPT-02 (Off-shore shelf)

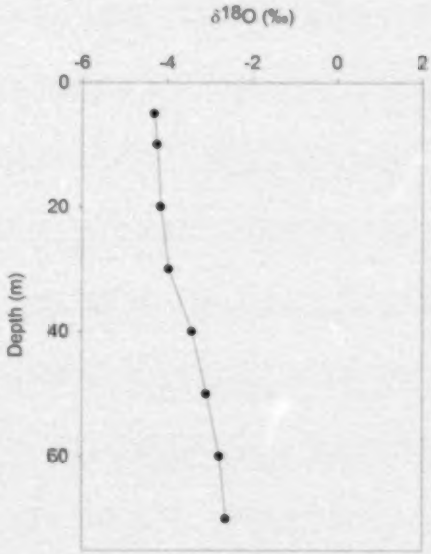


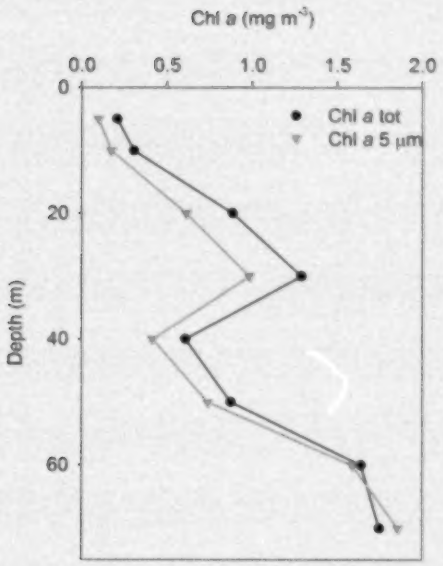


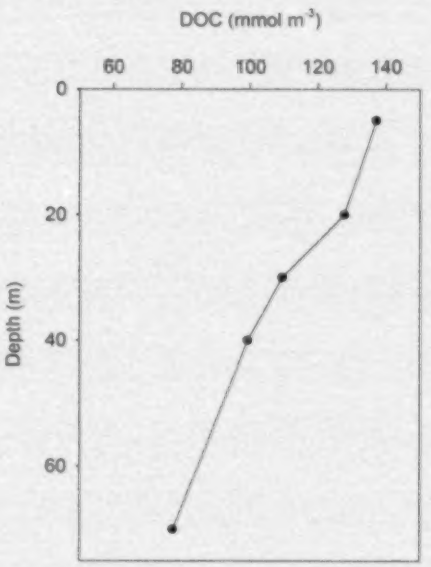


05/08/2013: Cast 8, Station BPT-02 (Off-shore shelf)

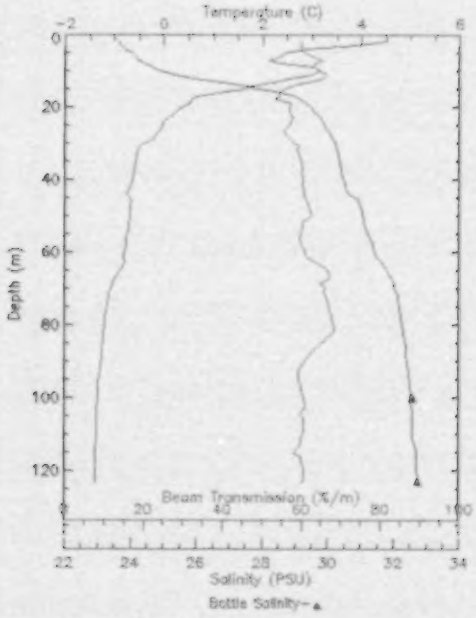


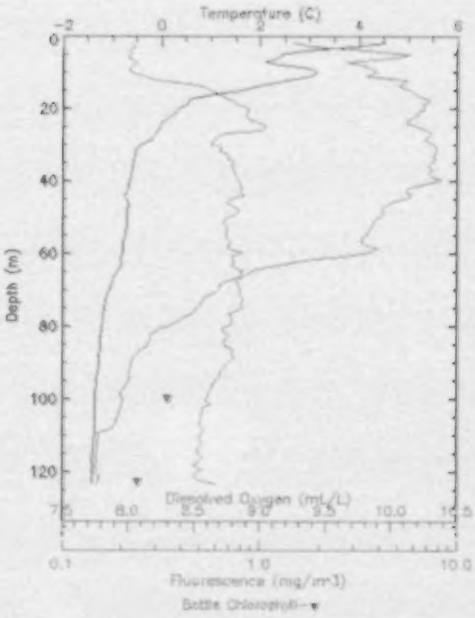


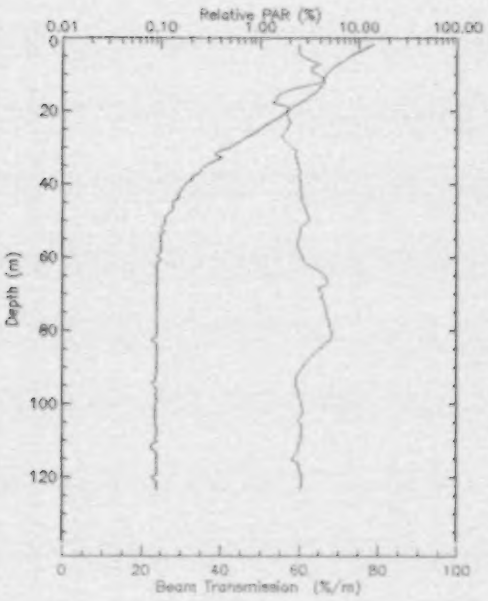




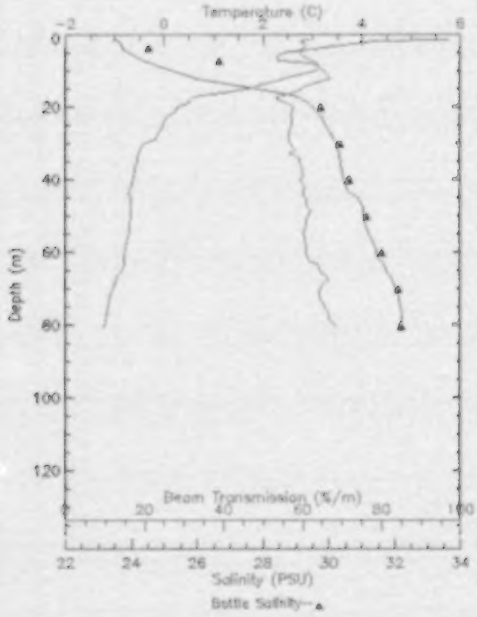
06/08/2013: Cast 9, Station BPT-03 (Off-shore shelf)

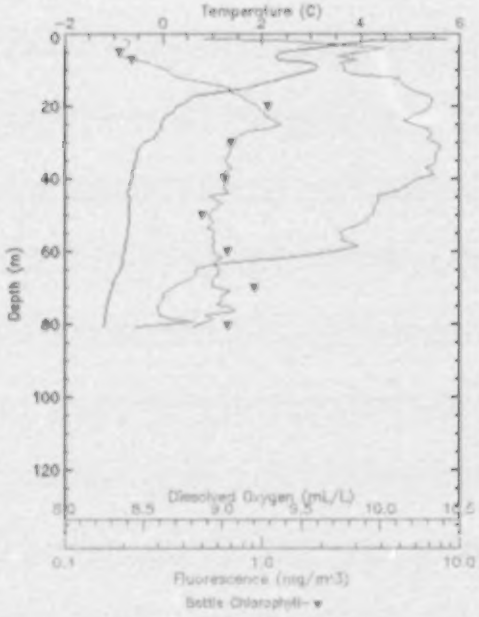


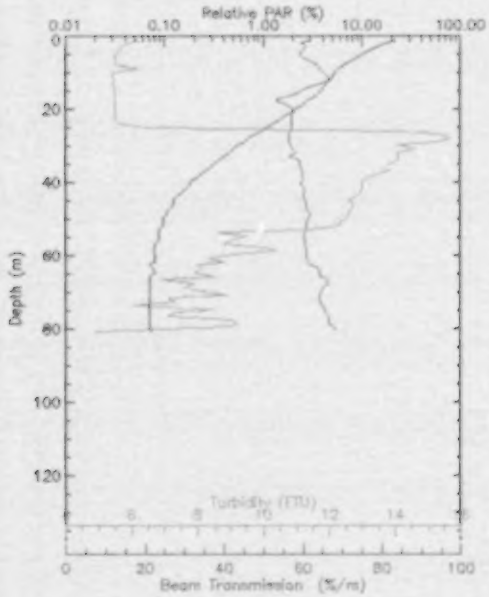




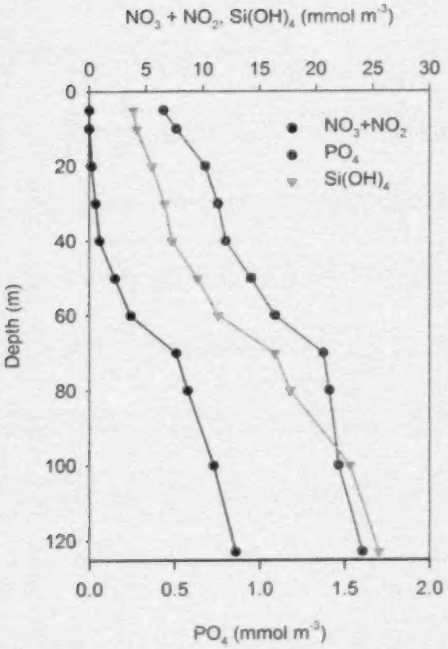
06/08/2013: Cast 10, Station BPT-03 (Off-shore shelf)

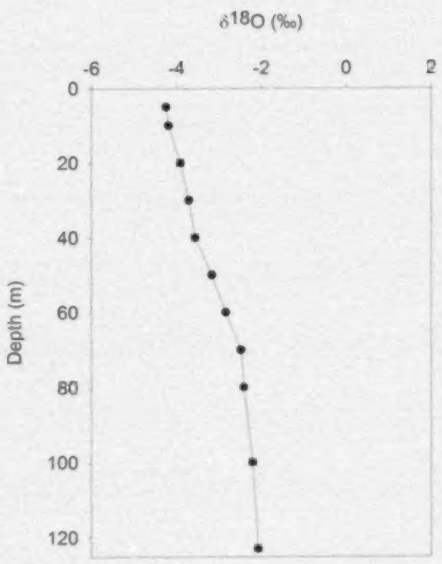


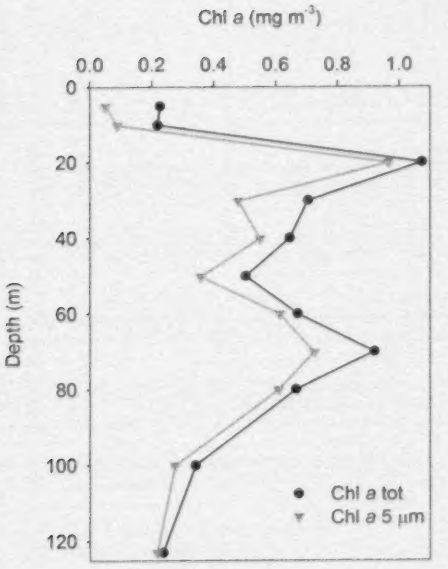


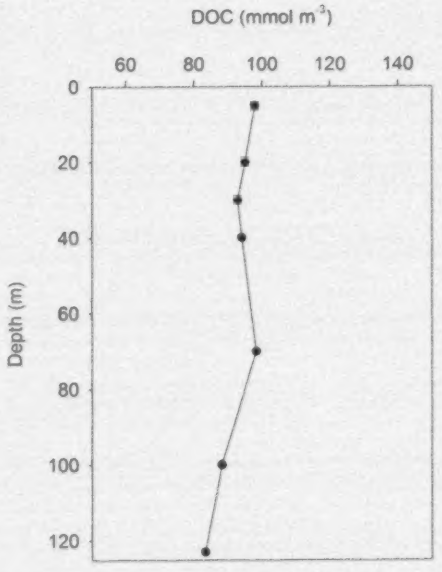


06/08/2013: Cast 9/10, Station BPT-03 (Off-shore shelf)

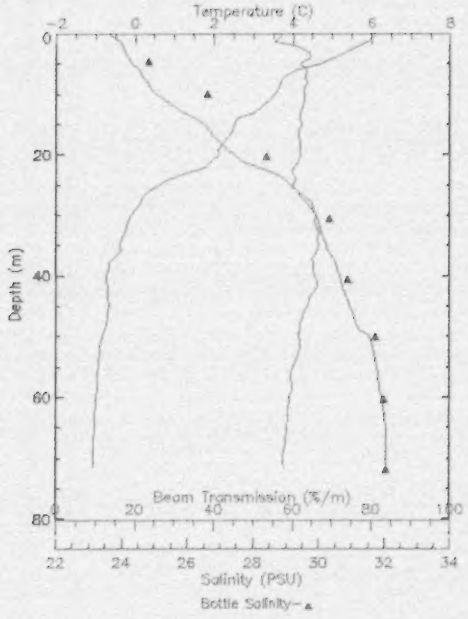


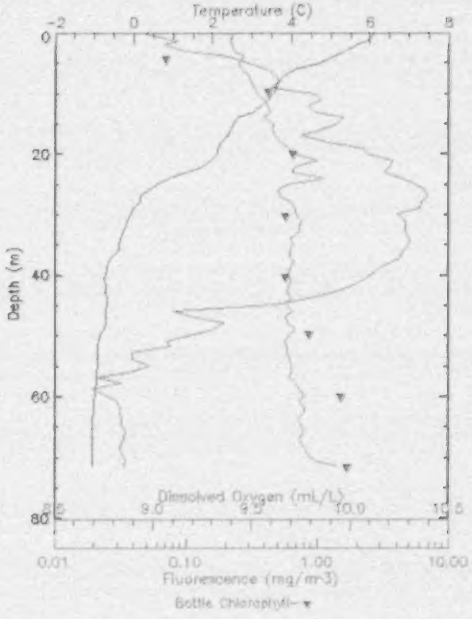


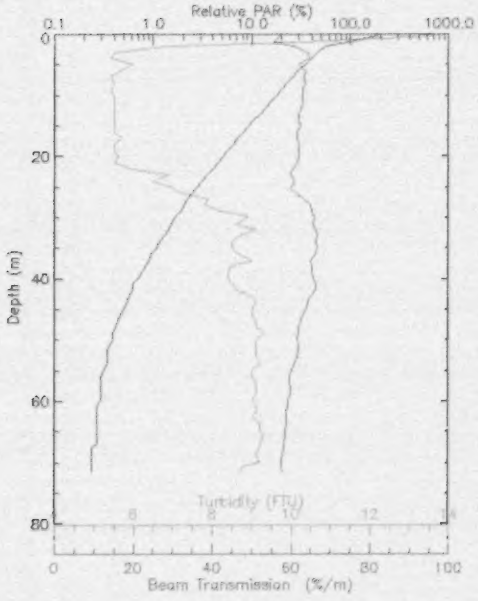




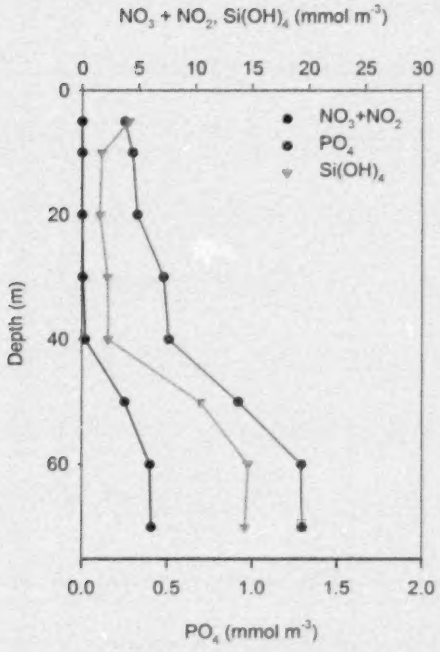
06/08/2013: Cast 11, Station BPT-04 (Near-shore shelf)

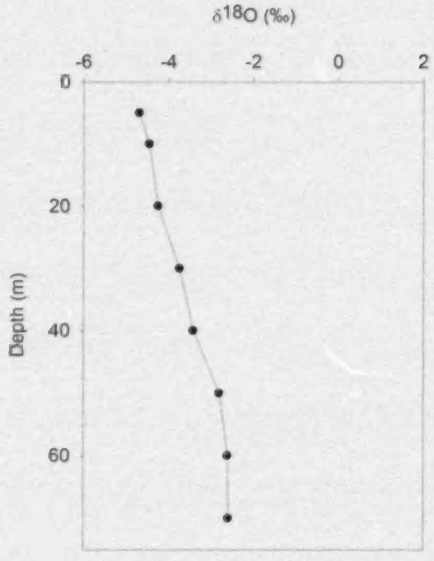


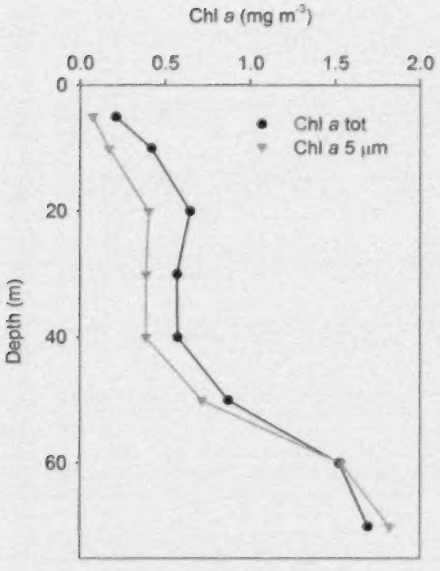


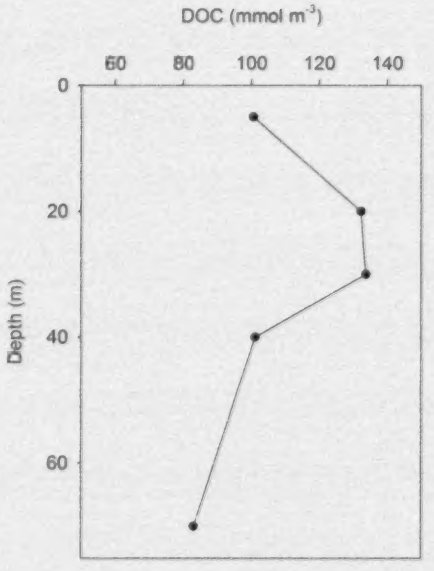


06/08/2013: Cast 11, Station BPT-04 (Near-shore shelf)

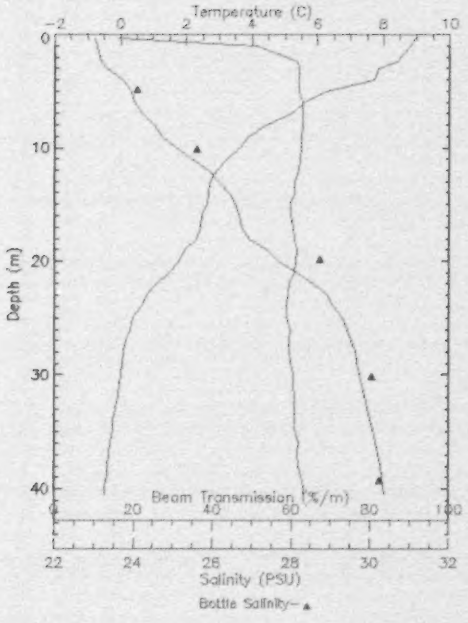


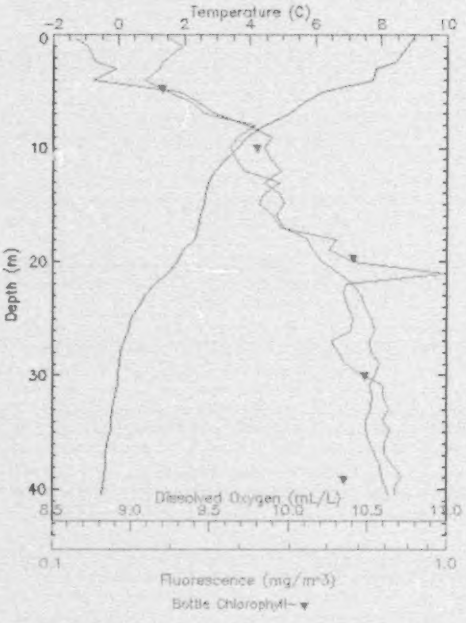


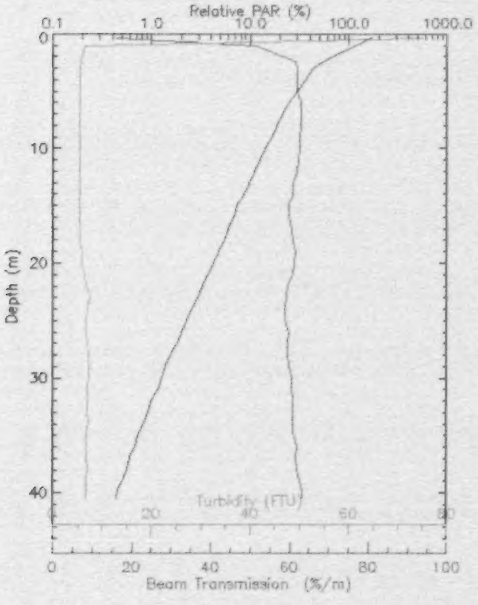




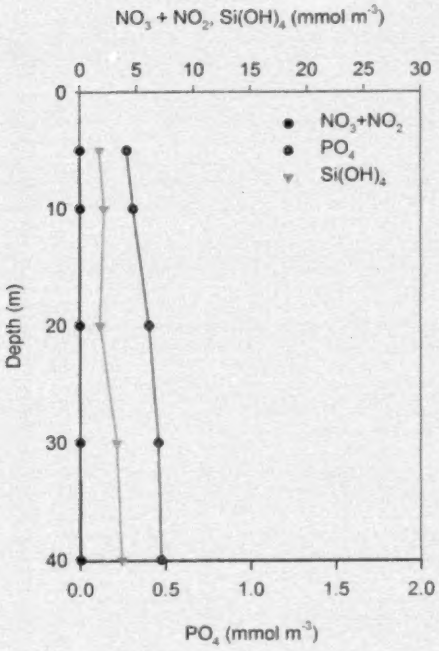
06/08/2013: Cast 12, Station BPT-05 (Near-shore shelf)

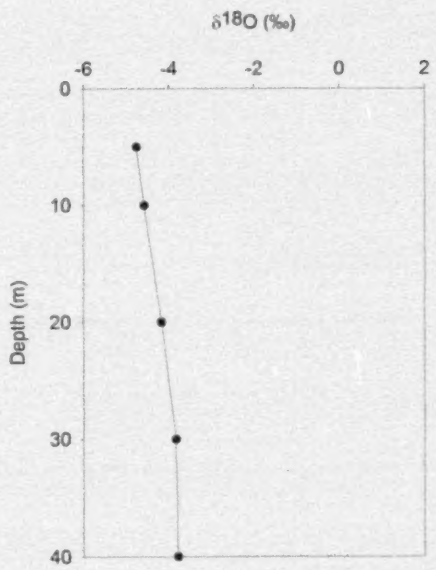


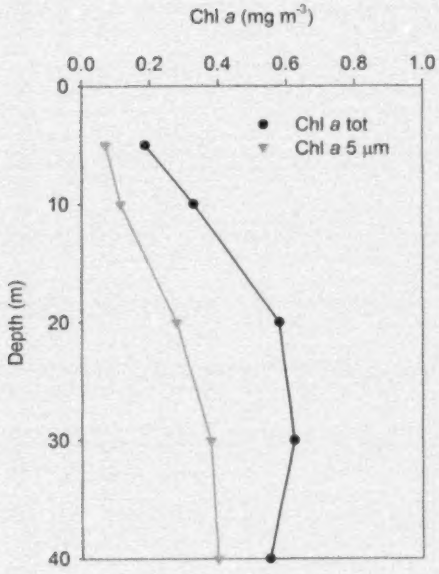


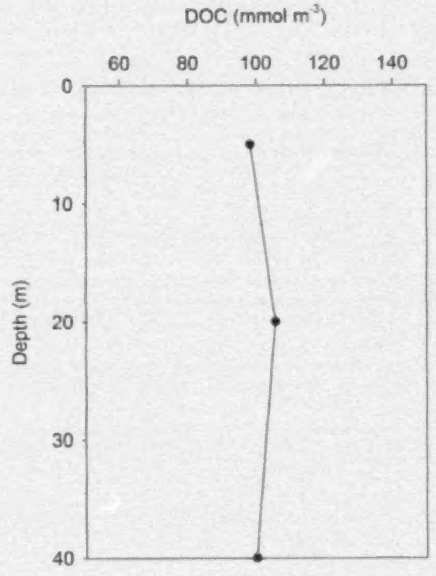


06/08/2013: Cast 12, Station BPT-05 (Near-shore shelf)

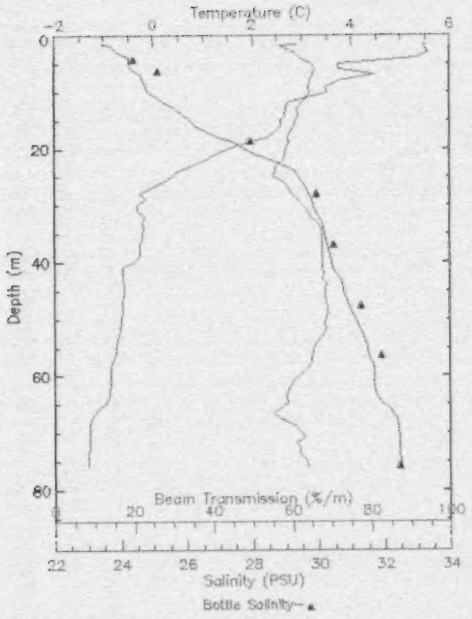


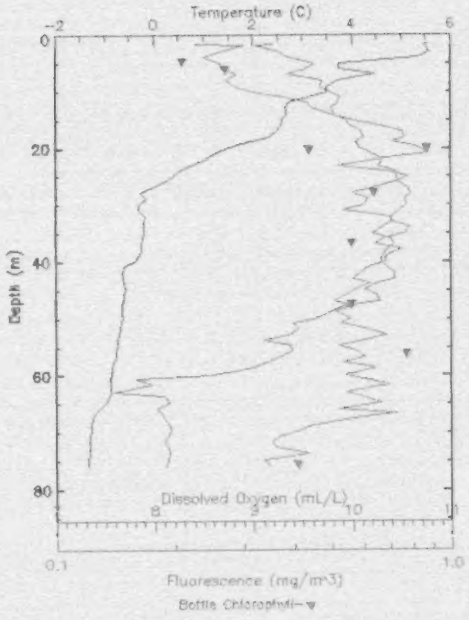


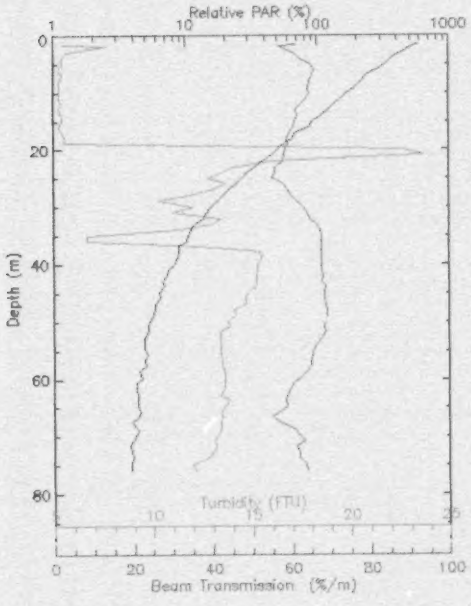




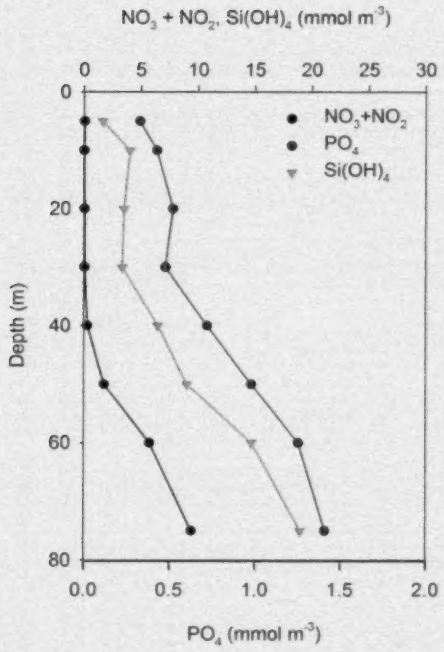
07/08/2013: Cast, Station DAR-02 (Off-shore shelf)

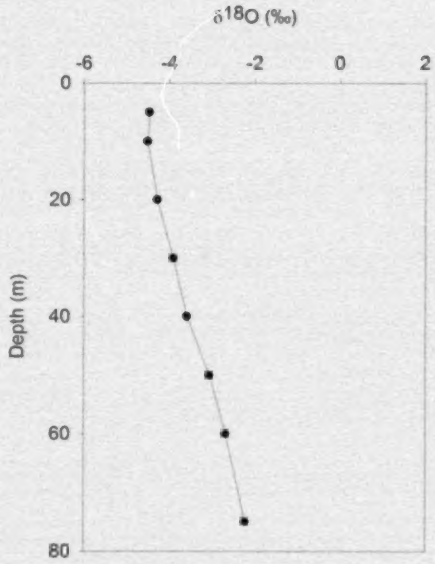


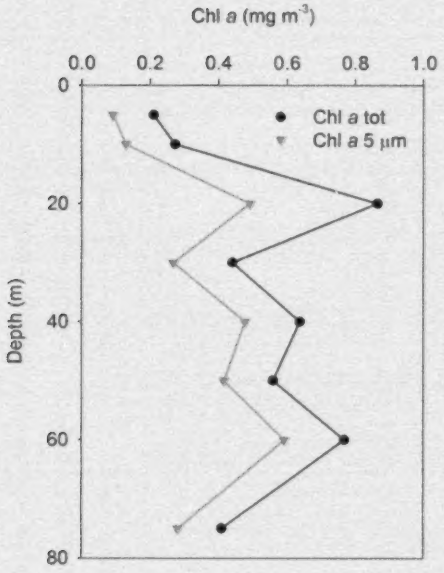


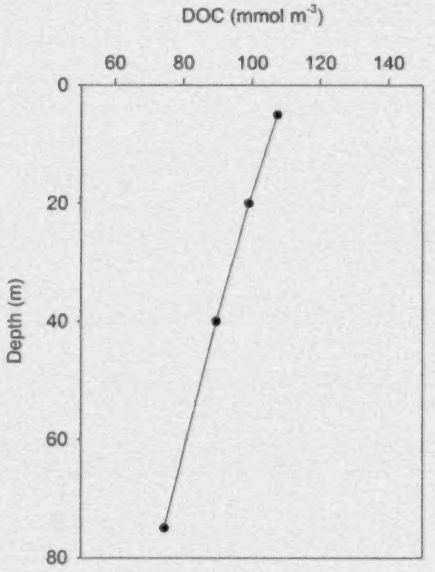


07/08/2013: Cast, Station DAR-02 (Off-shore shelf)

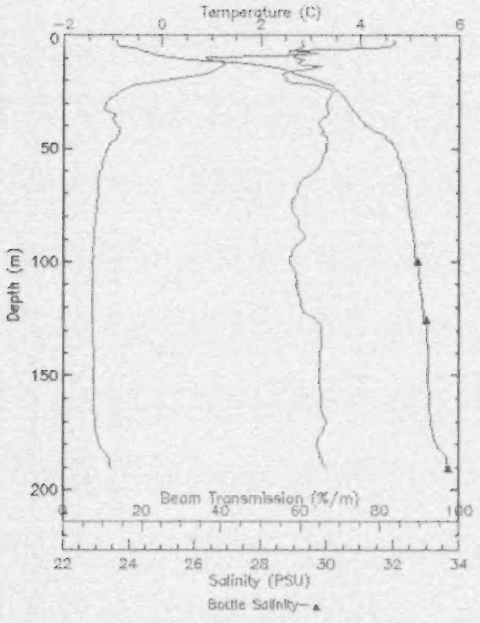


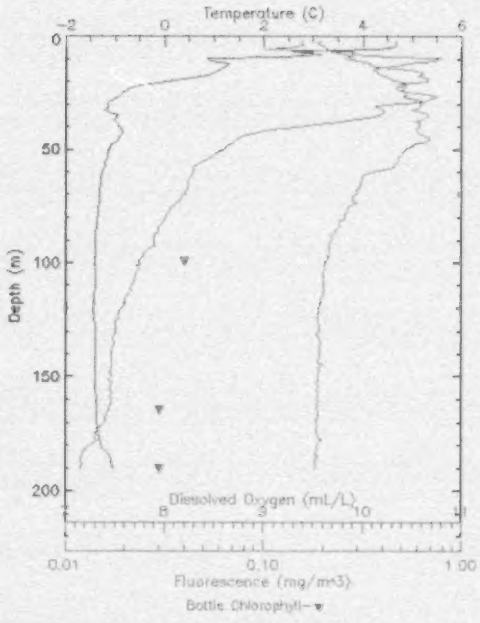


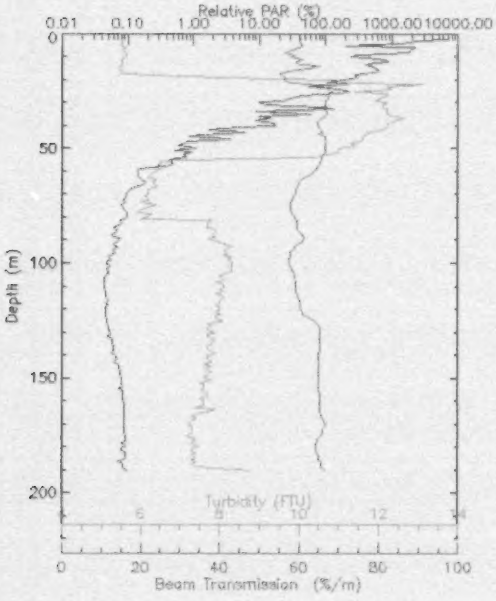




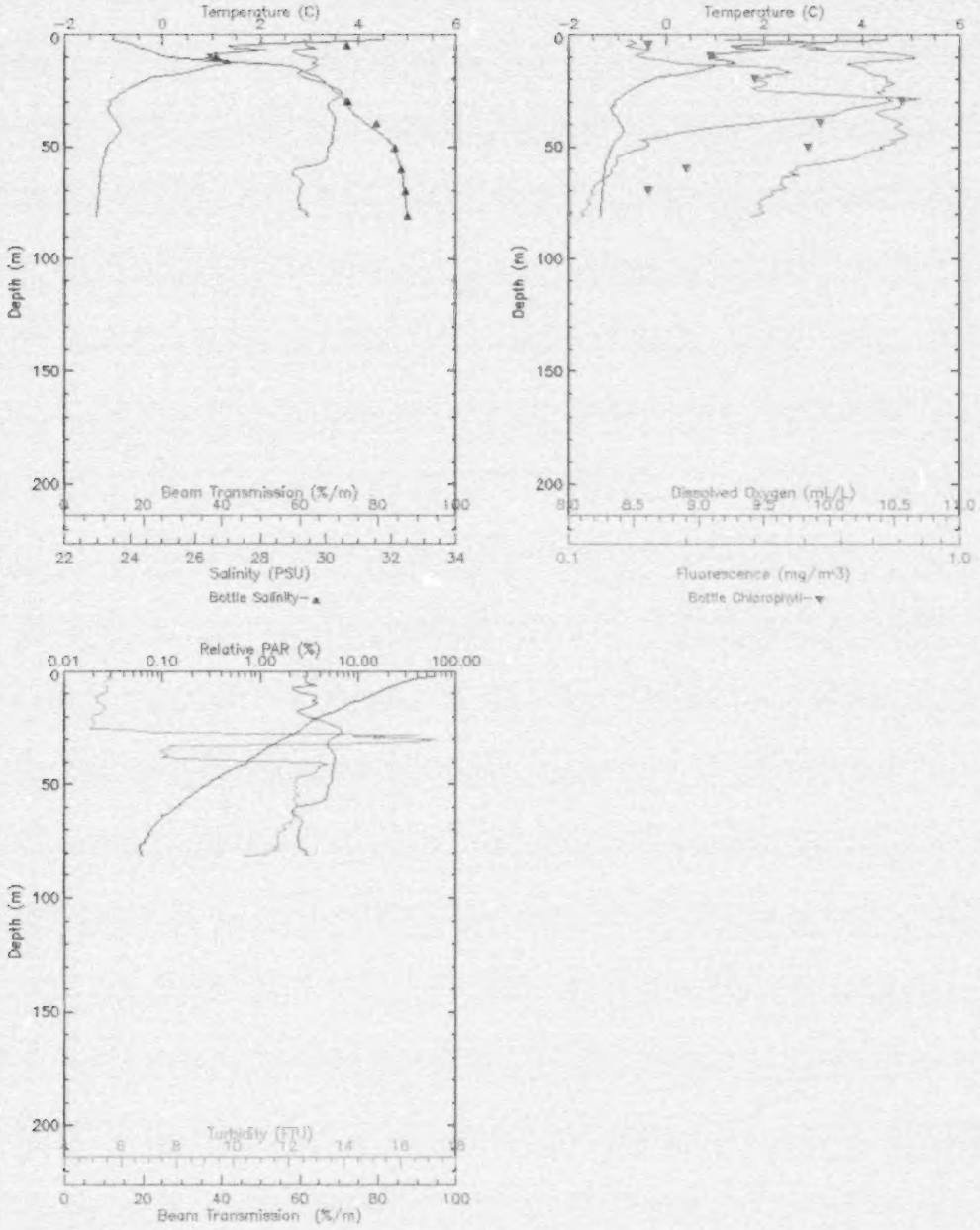
07/08/2013: Cast 14, Station DAR-03 (Off-shore shelf)



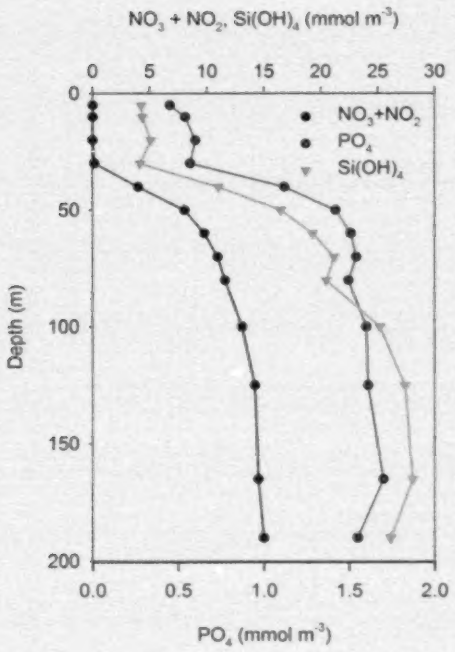


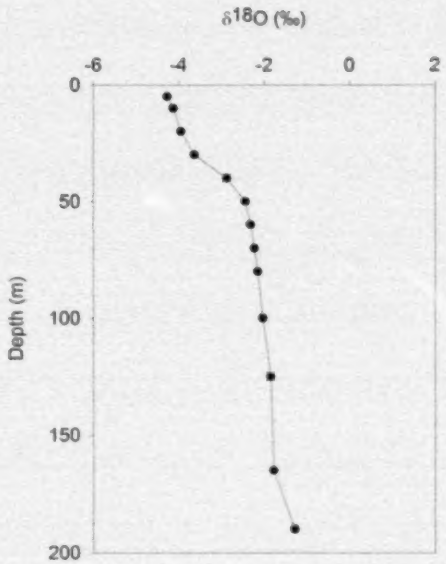


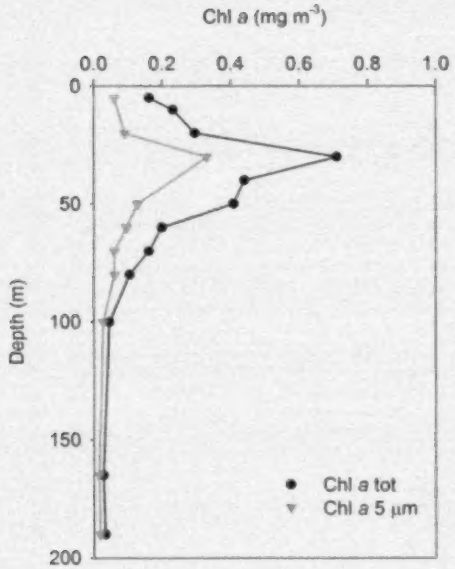
07/08/2013: Cast 15, Station DAR-03 (Off-shore shelf)

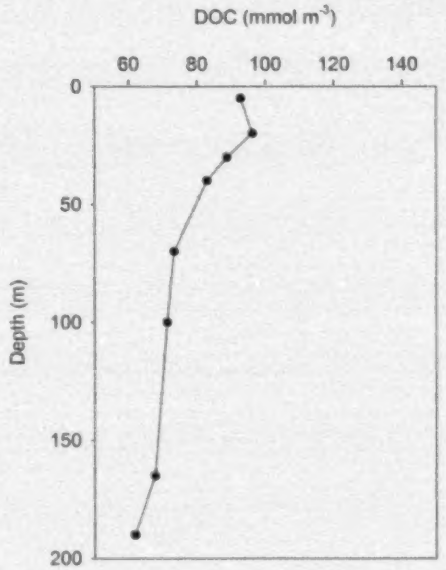


07/08/2013: Cast 14/15, Station DAR-03 (Off-shore shelf)

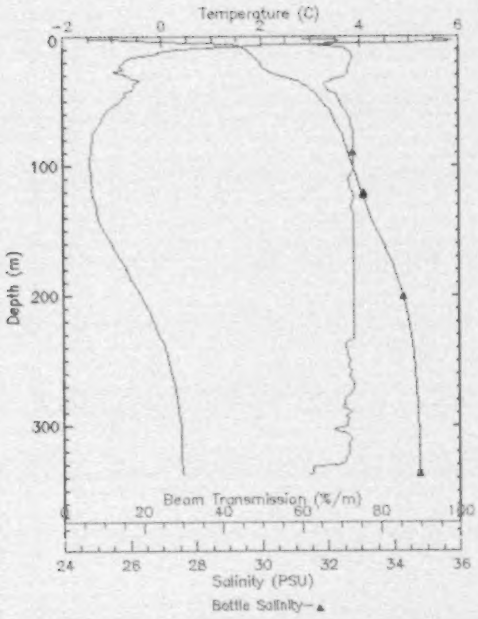


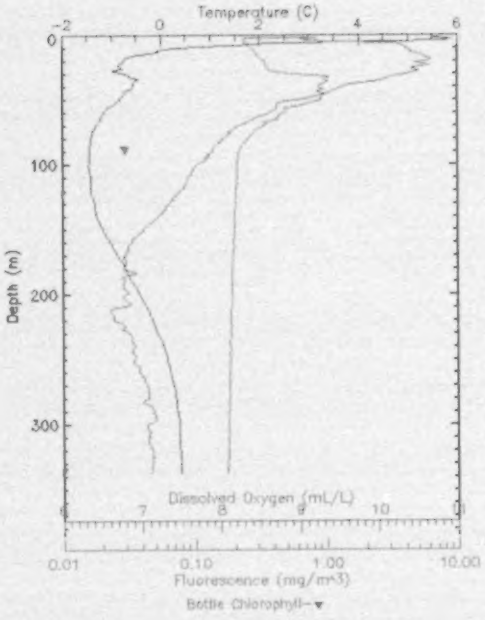


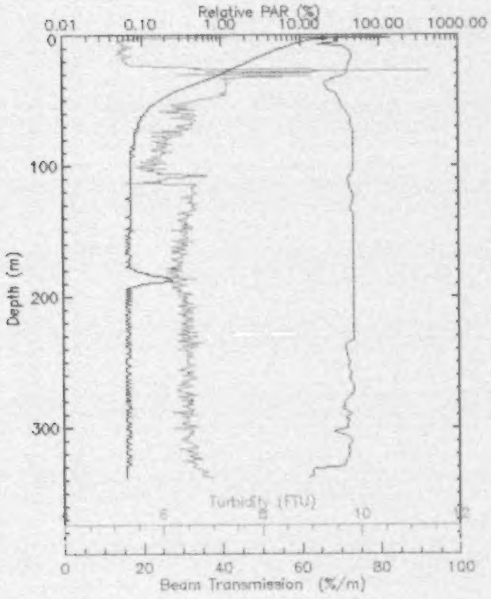




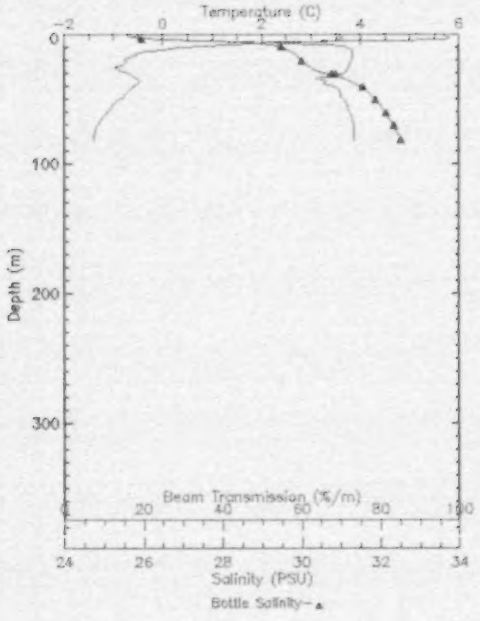
08/08/2013: Cast 16, Station DAR-04 (Upper slope)

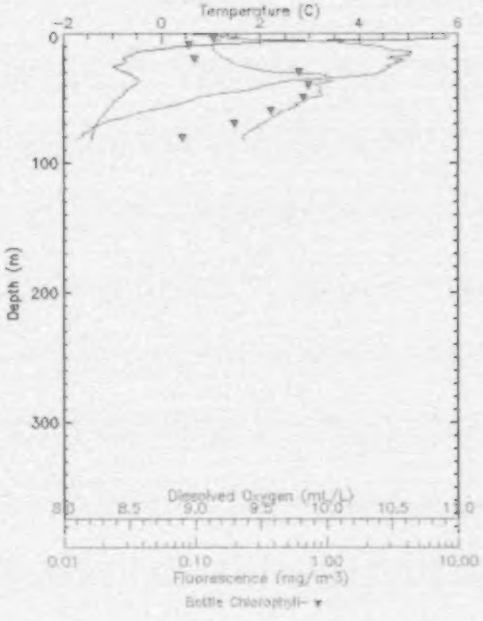


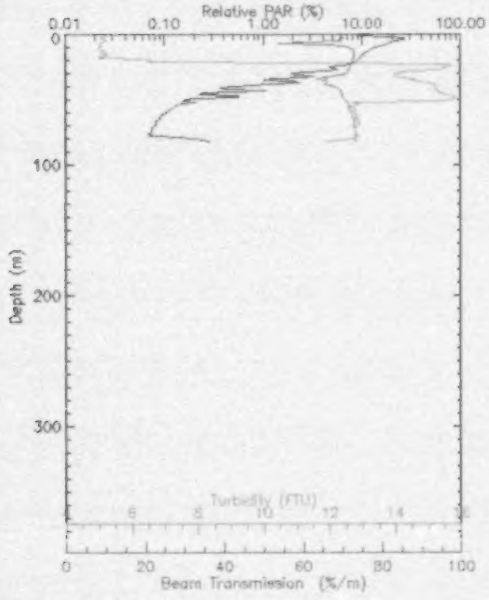




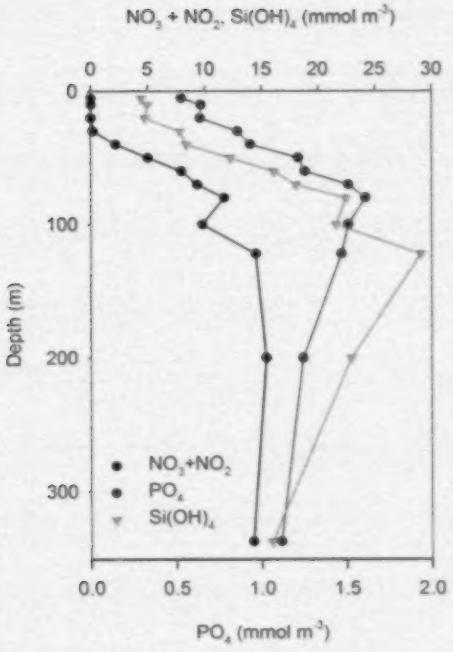
08/08/2013: Cast 17, Station DAR-04 (Upper slope)

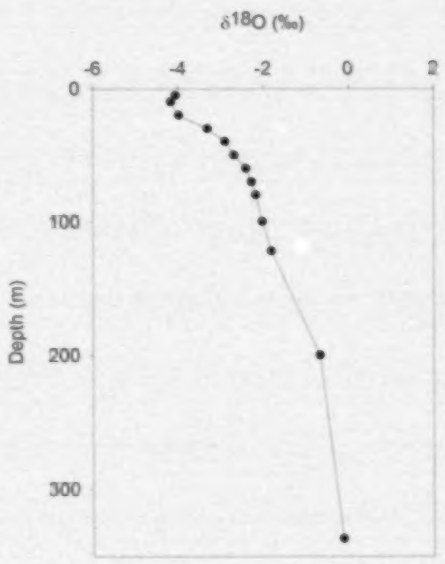


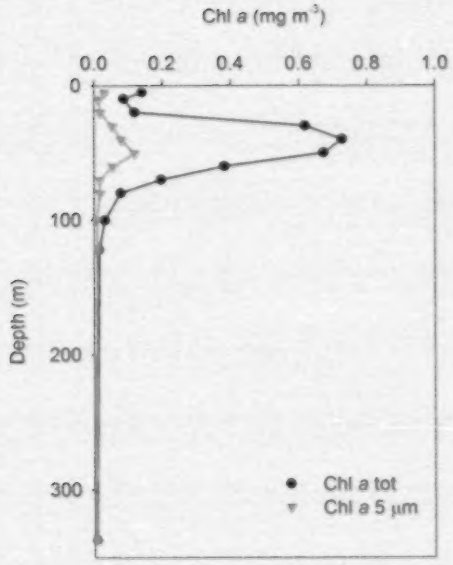


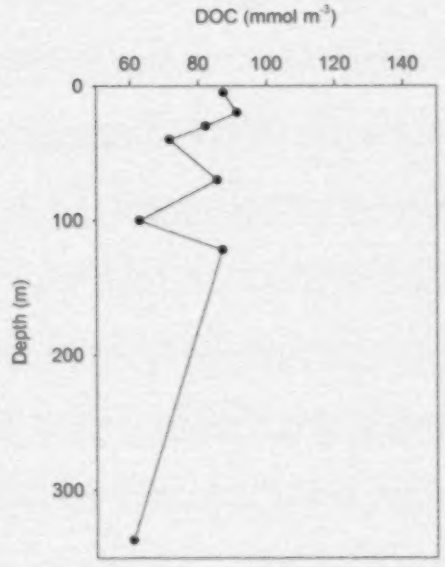


08/08/2013: Cast 16/17, Station DAR-04 (Upper slope)

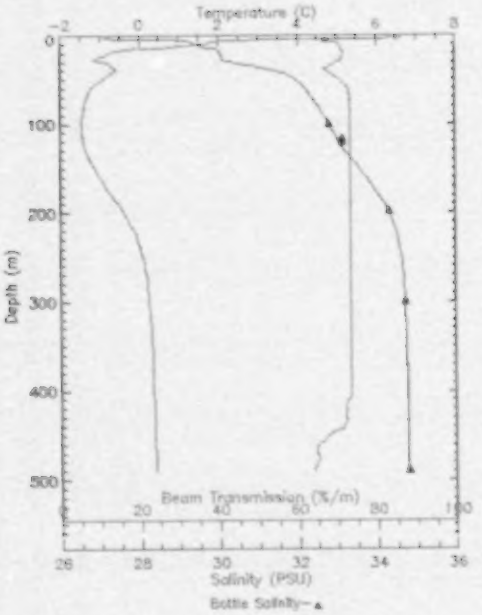


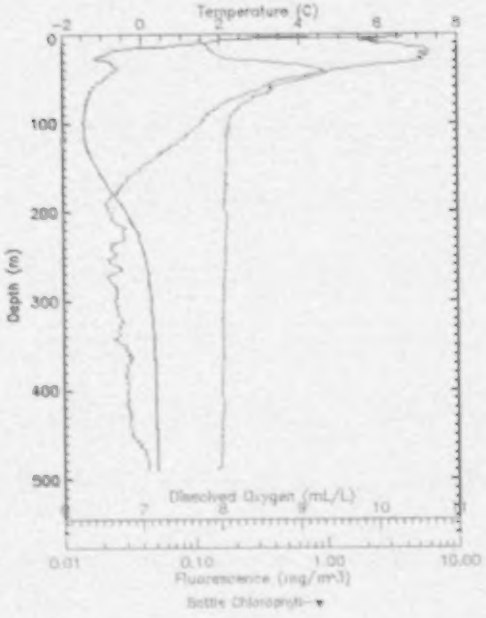


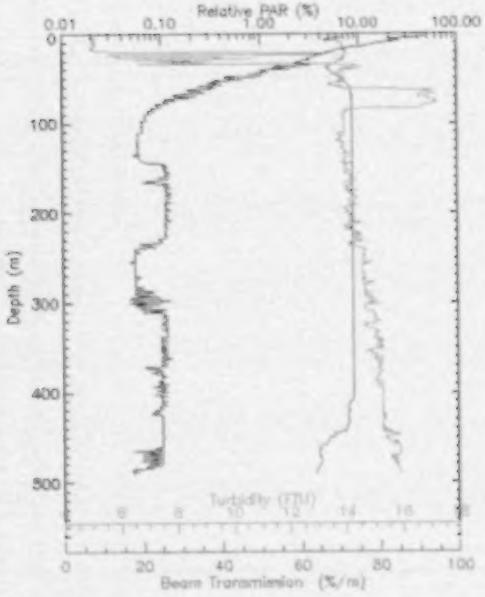




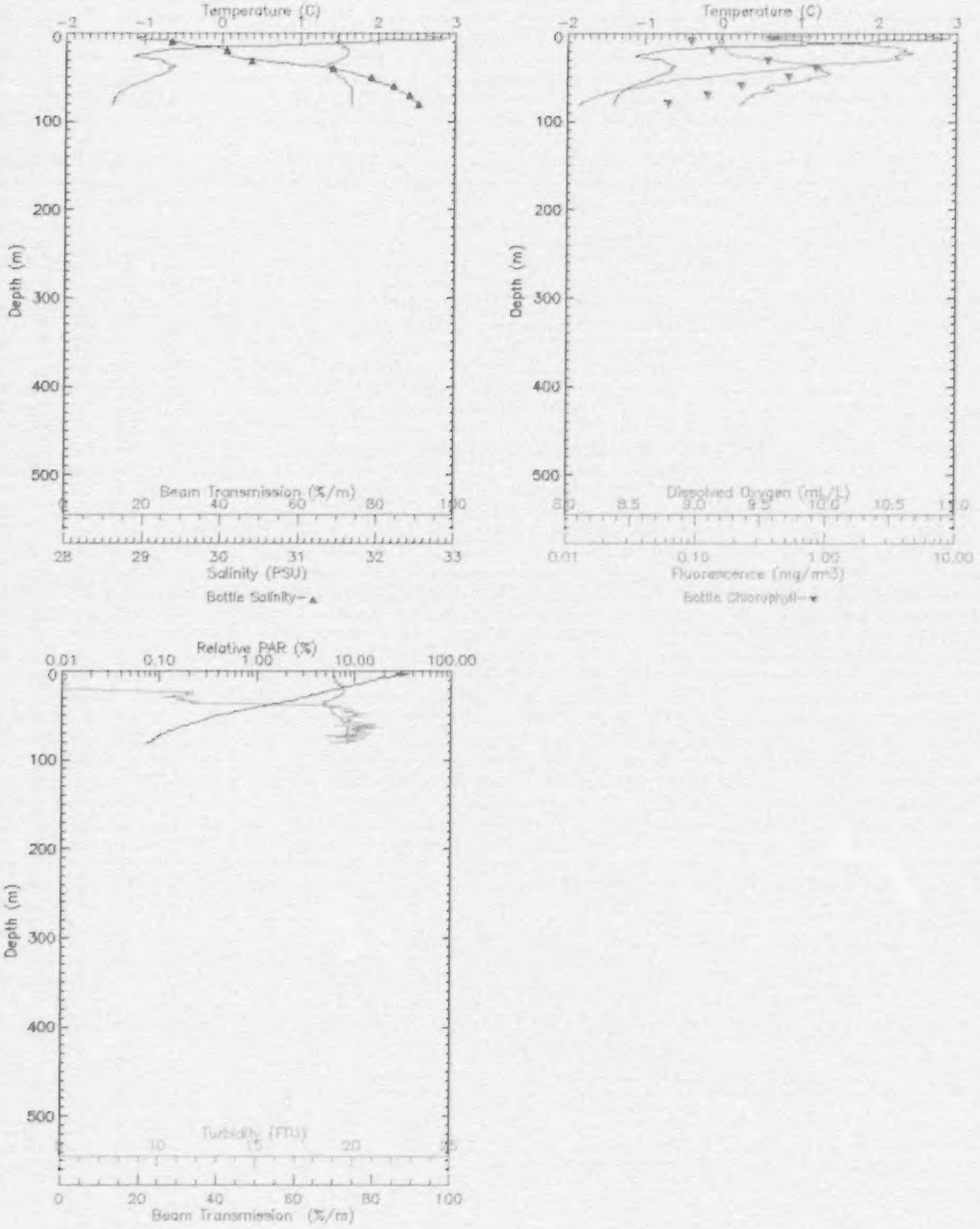
08/08/2013: Cast 18, Station DAR-05 (Lower slope)



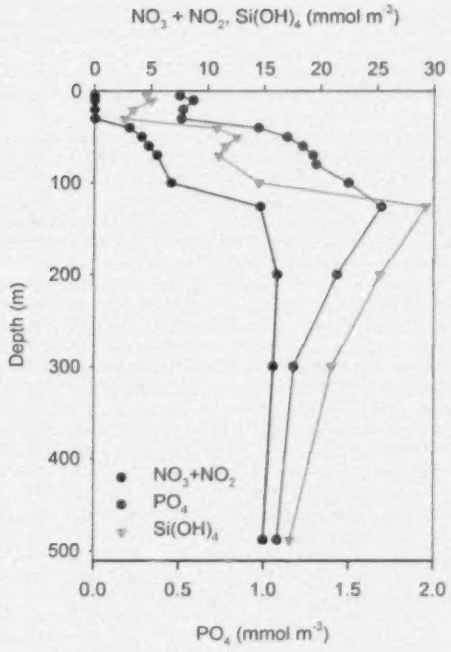


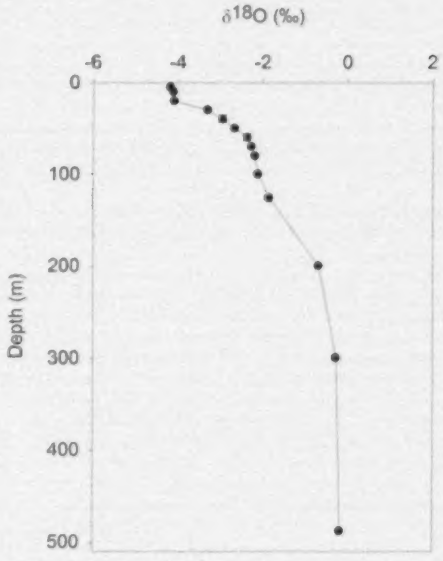


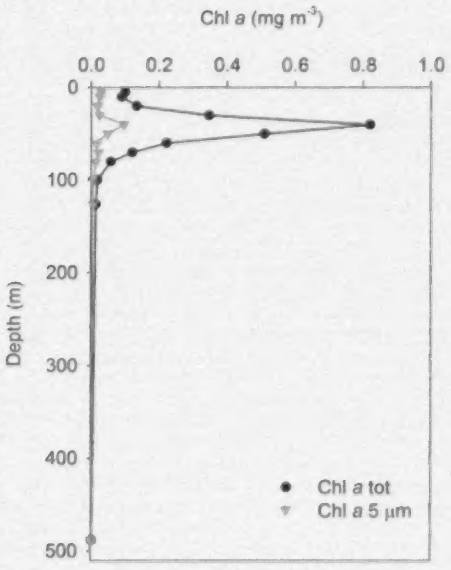
08/08/2013: Cast 19, Station DAR-05 (Lower slope)

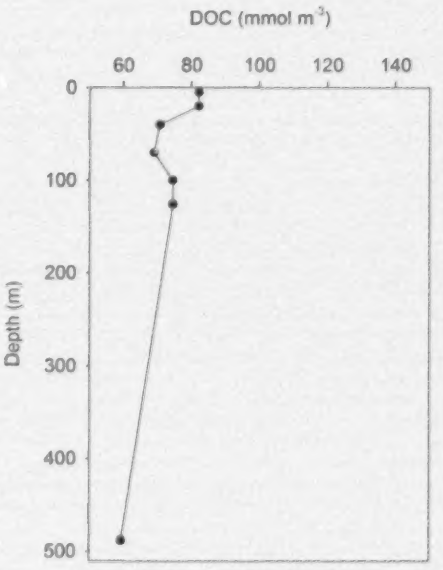


08/08/2013: Cast 18/19, Station DAR-05 (Lower slope)

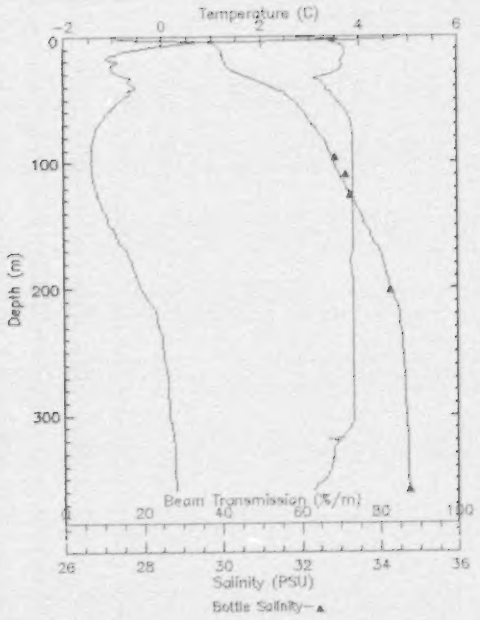


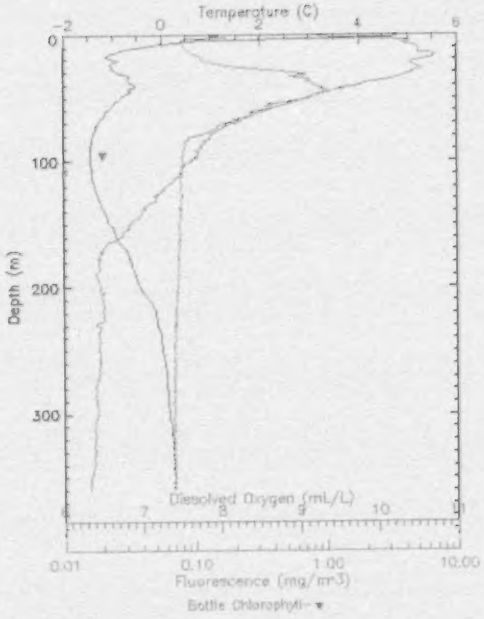


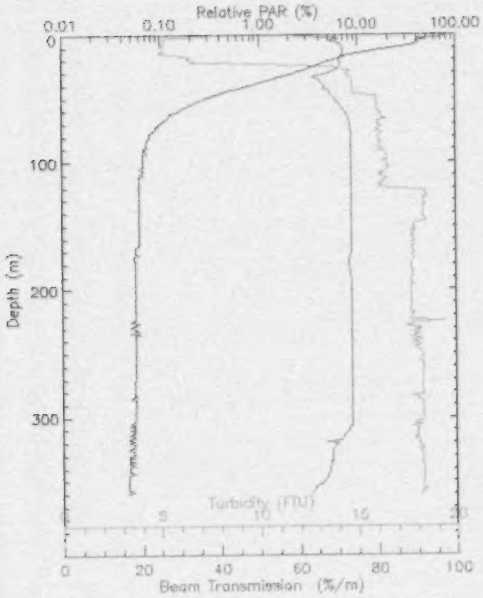




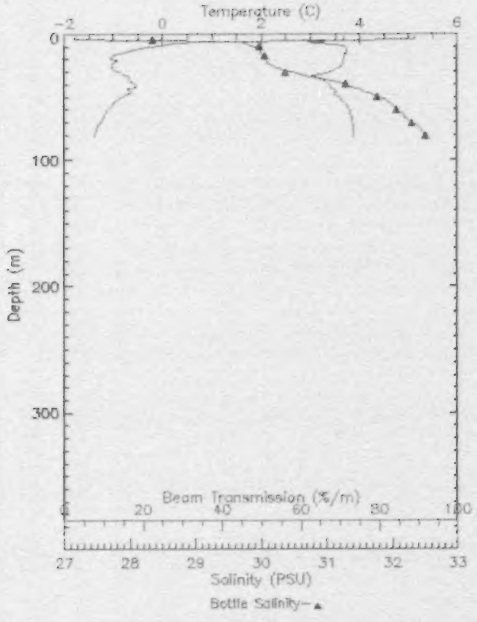
09/08/2013: Cast 20, Station DAR-06 (Upper slope)

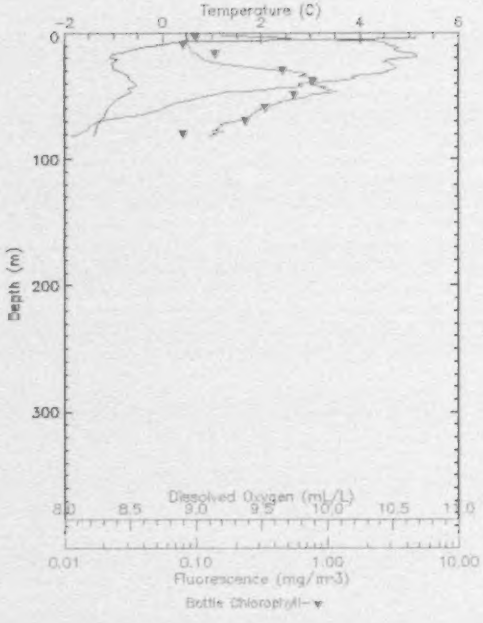


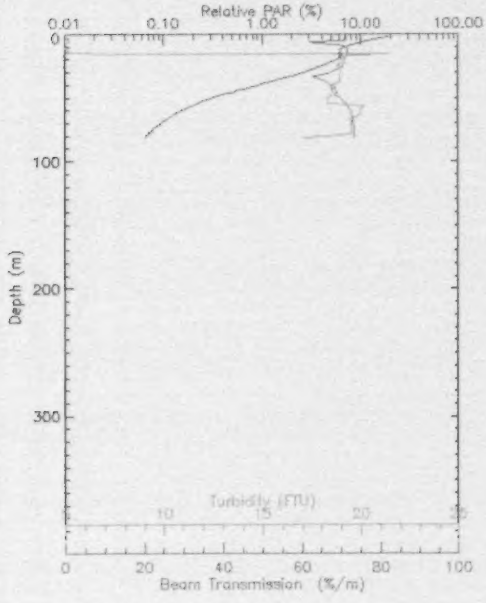




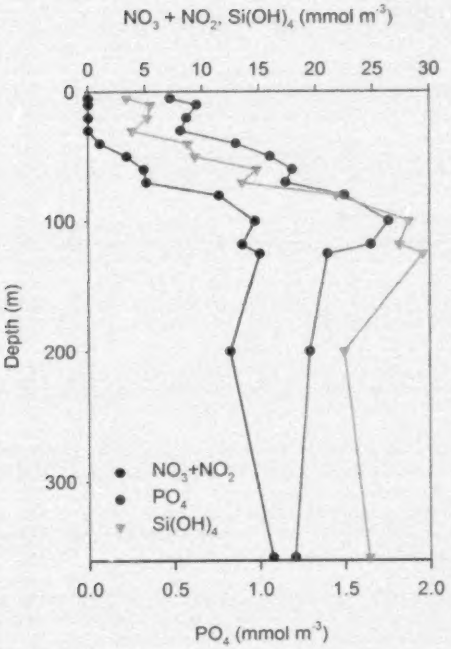
09/08/2013: Cast 21, Station DAR-06 (Upper slope)

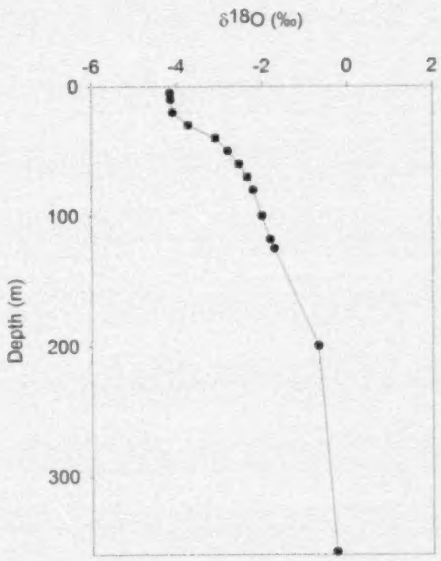


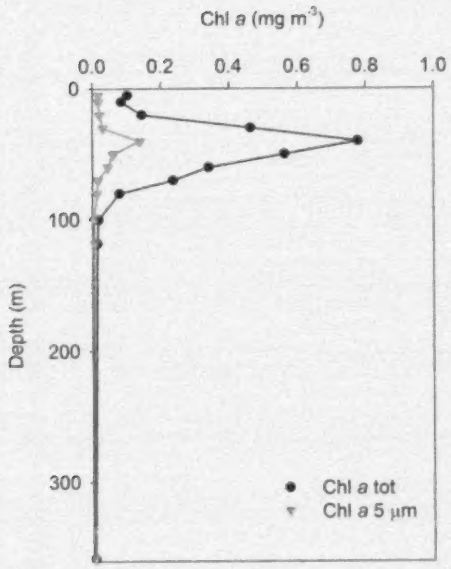


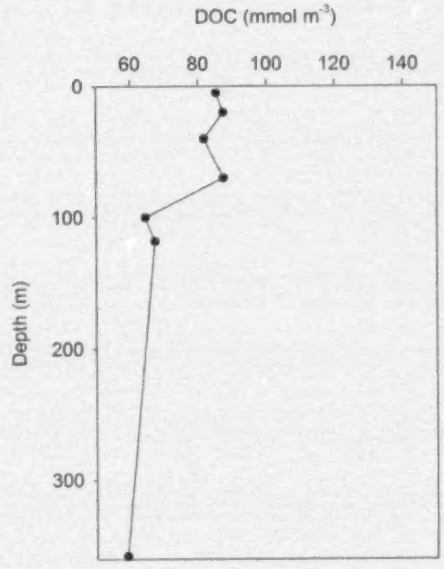


09/08/2013: Cast 20/21, Station DAR-06 (Upper slope)

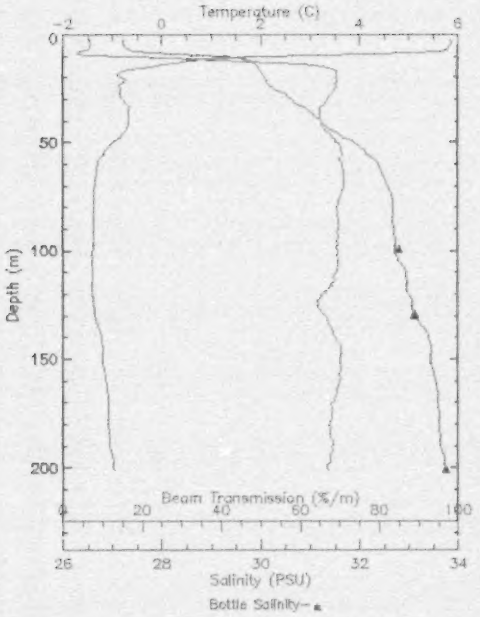


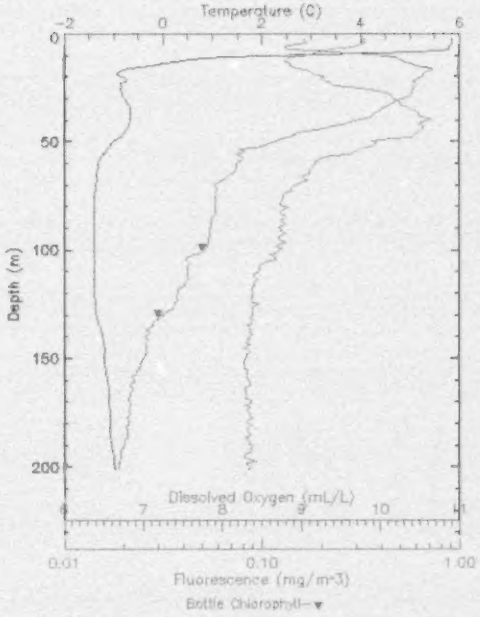


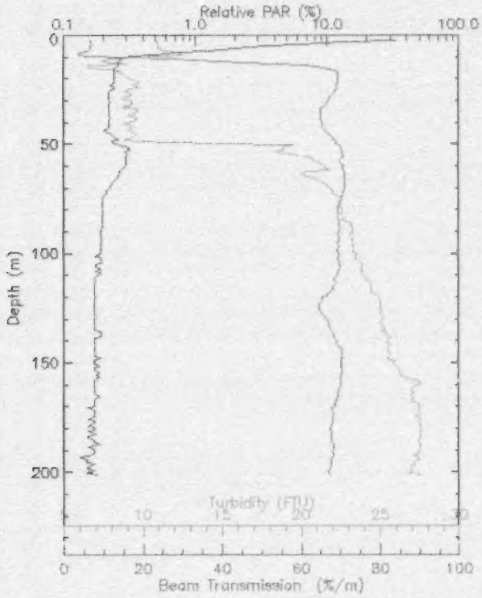




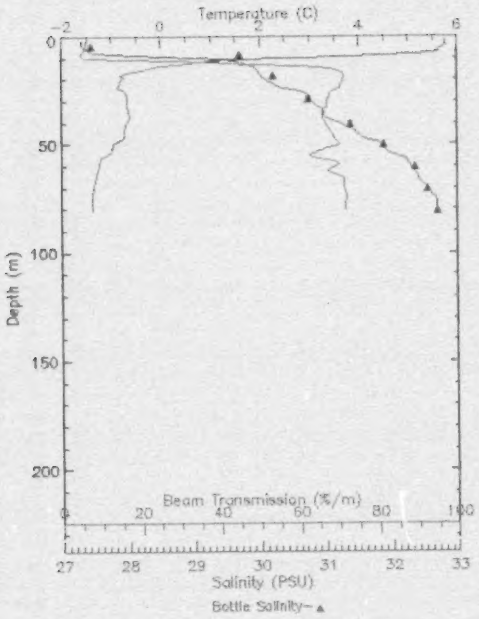
10/08/2013: Cast 22, Station DAR-07 (Upper slope)

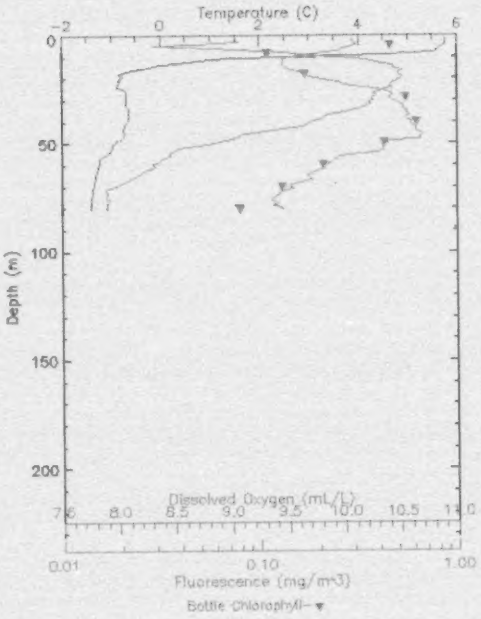


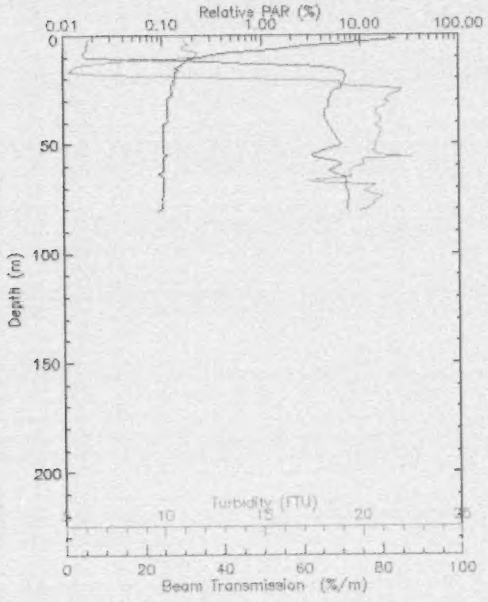




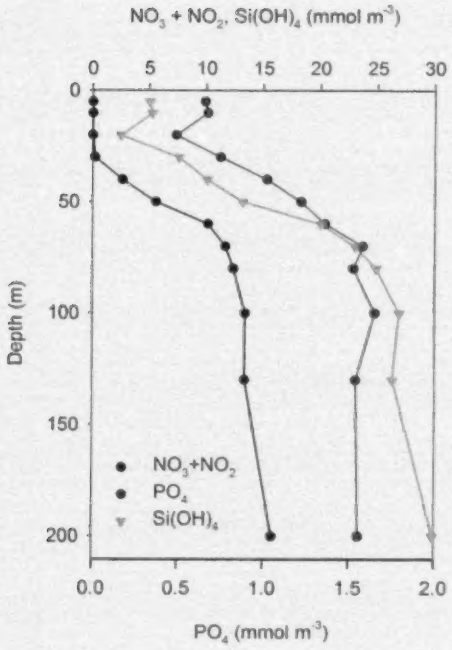
10/08/2013: Cast 23, Station DAR-07 (Upper slope)

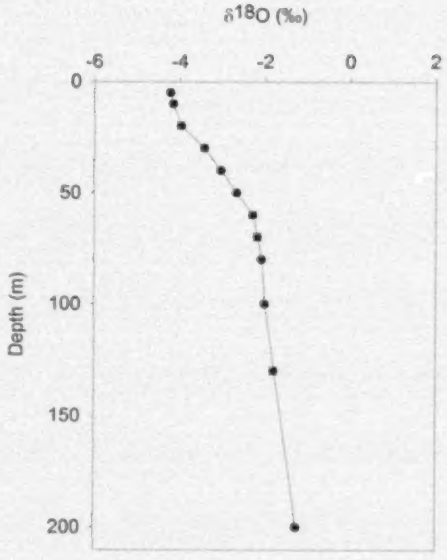


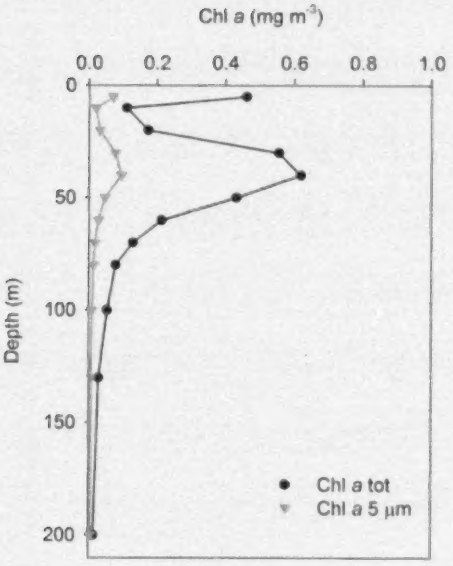


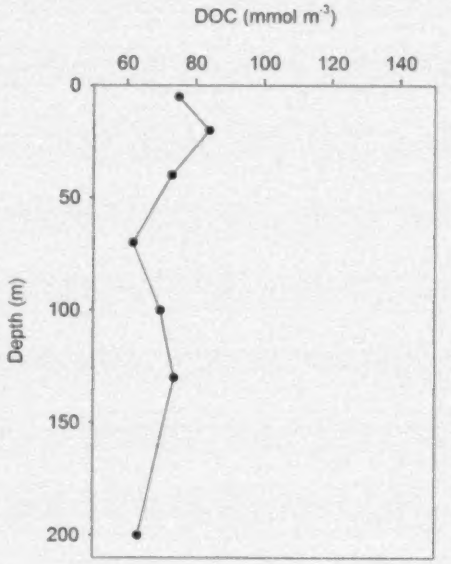


10/08/2013: Cast 22/23, Station DAR-07 (Upper slope)

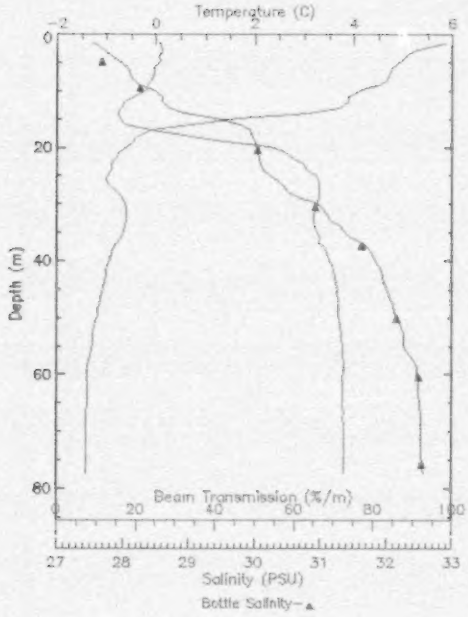


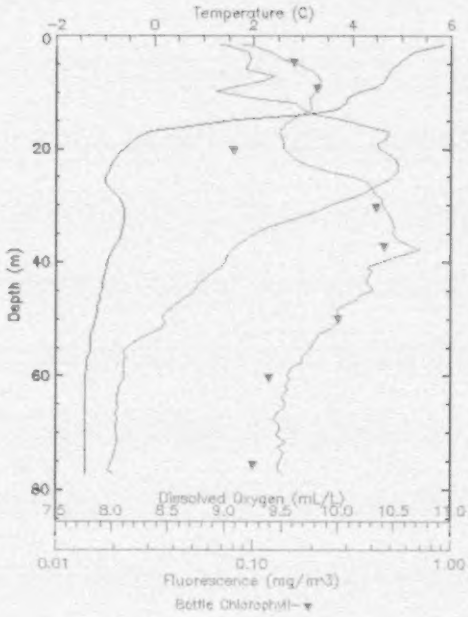


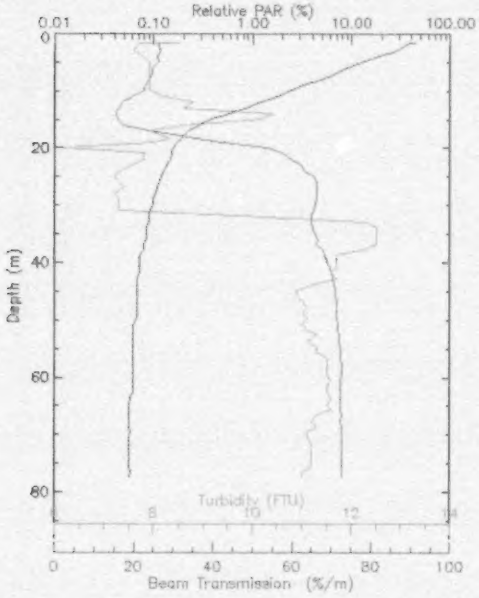




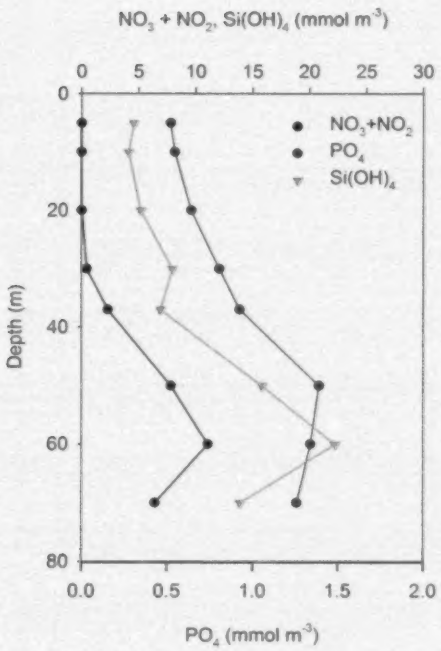
10/08/2013: Cast 24, Station DAR-08 (Off-shore shelf)

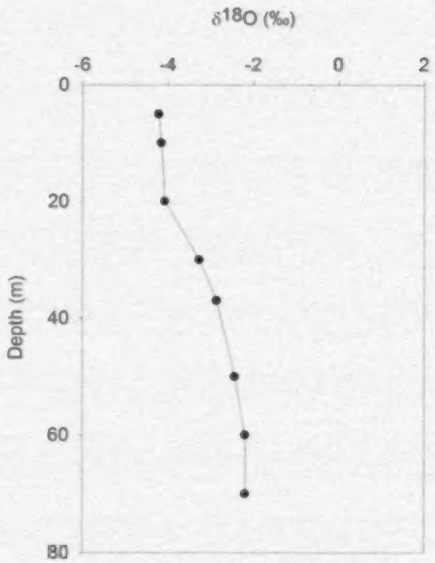


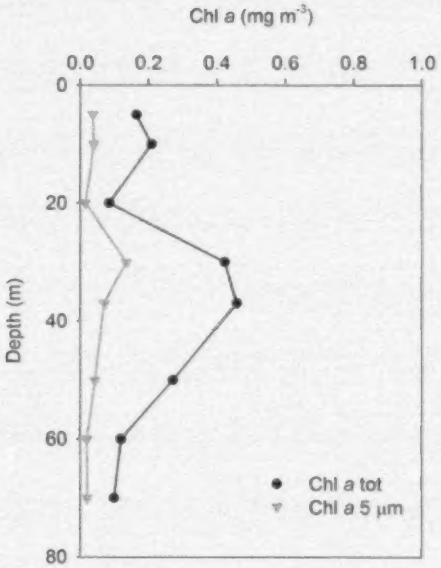


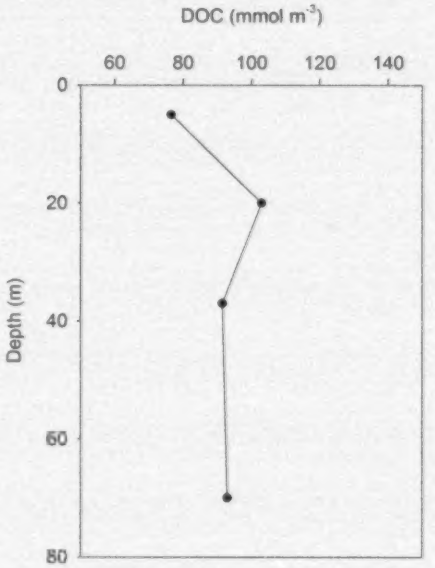


10/08/2013: Cast 24, Station DAR-08 (Off-shore shelf)

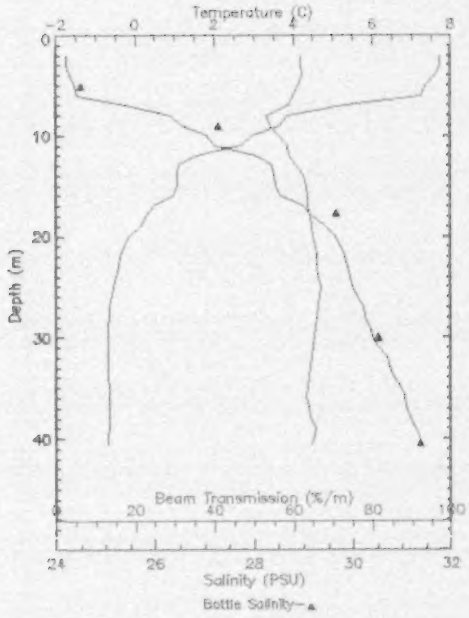


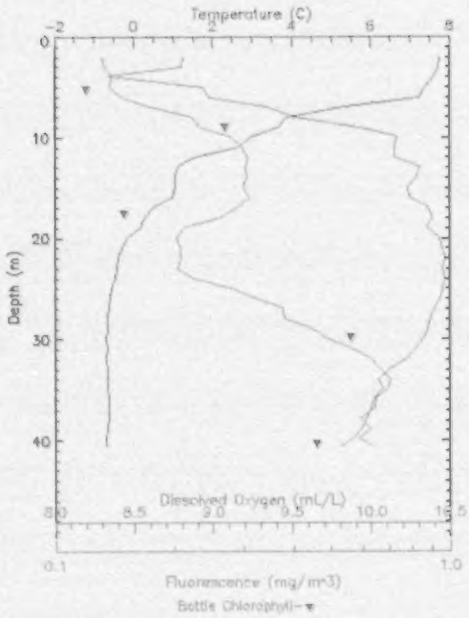


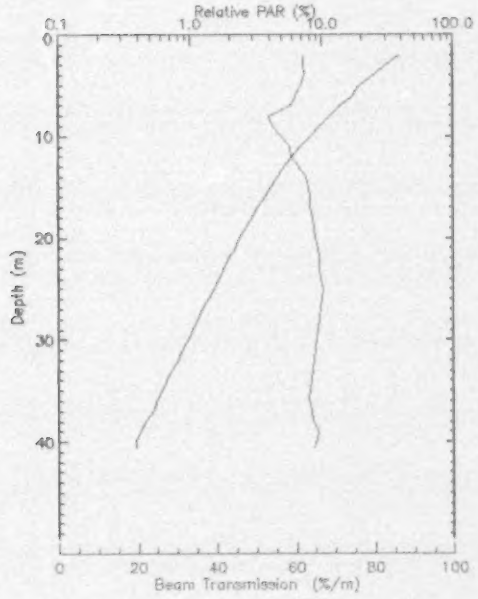




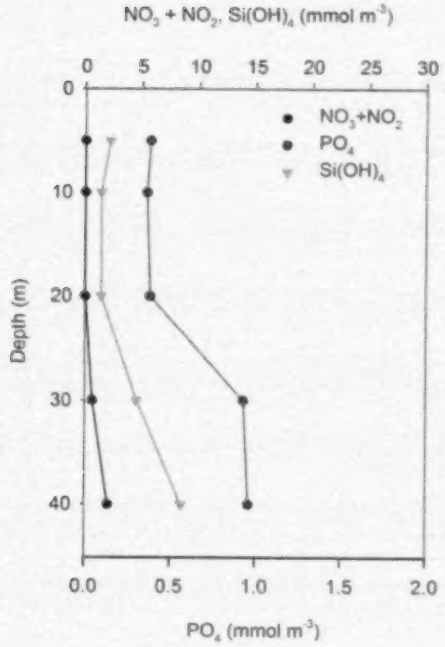
13/08/2013: Cast 25, Station ULU-01 (Near-shore shelf)

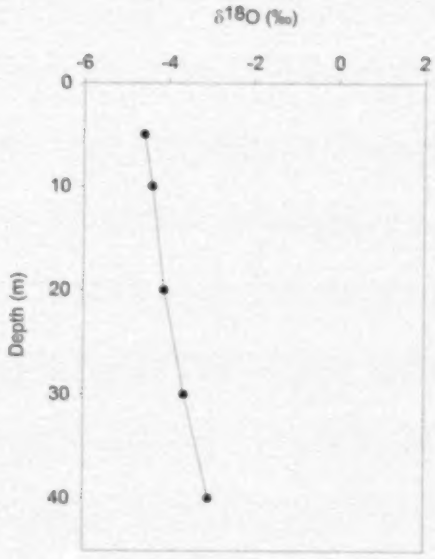


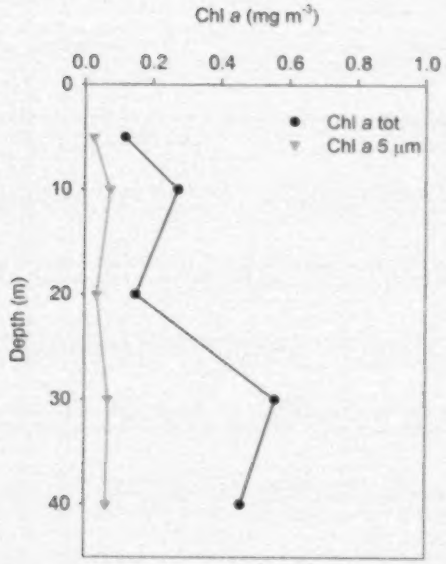


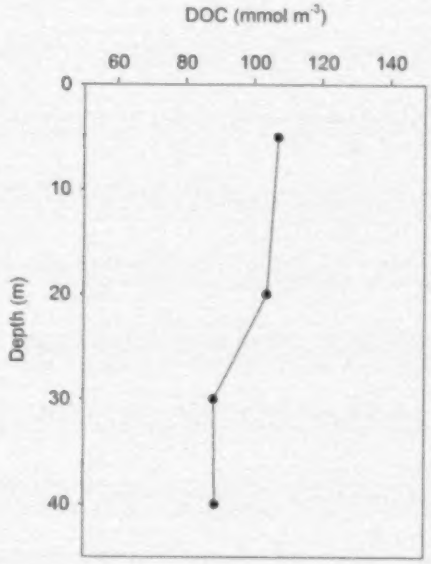


13/08/2013: Cast 25, Station ULU-01 (Near-shore shelf)

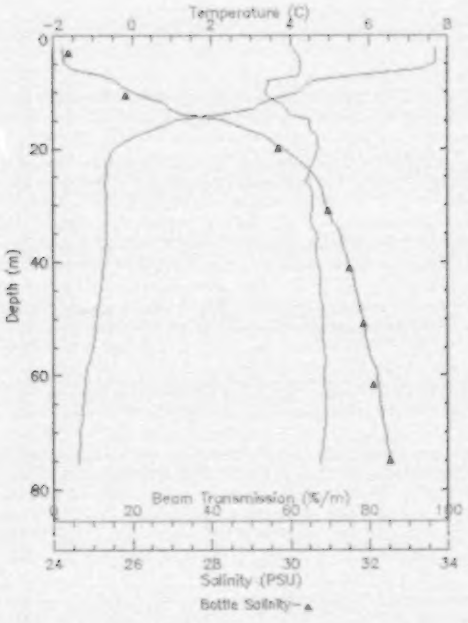


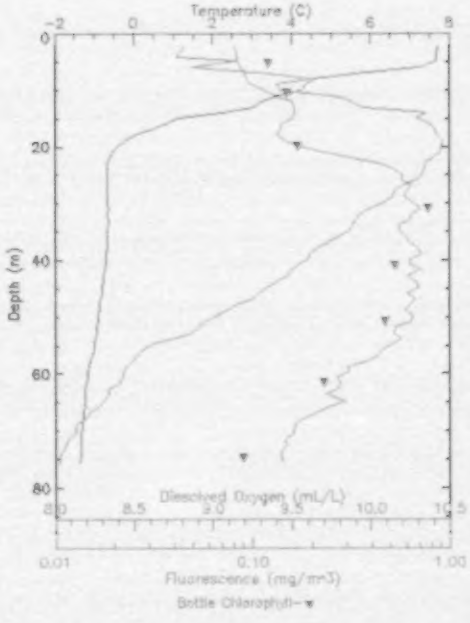


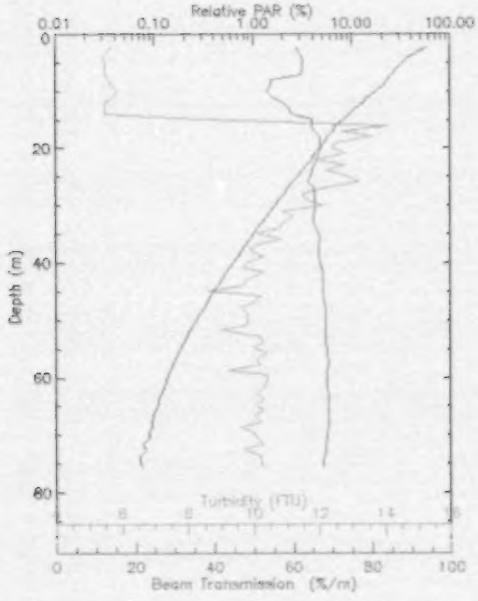




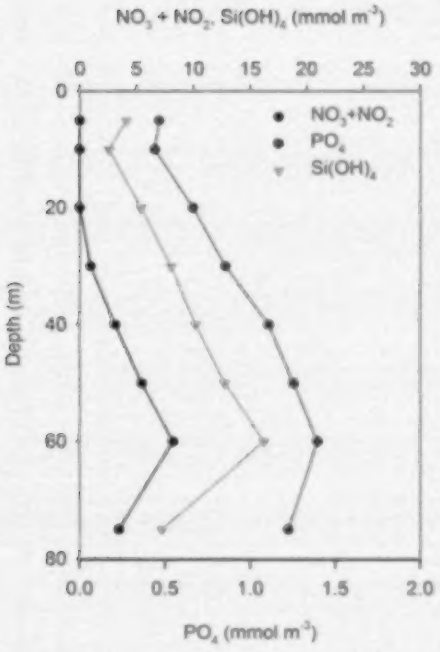
13/08/2013: Cast 26, Station ULU-02 (Off-shore shelf)

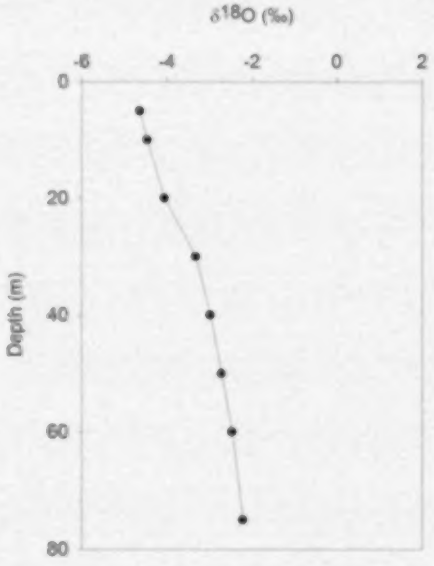


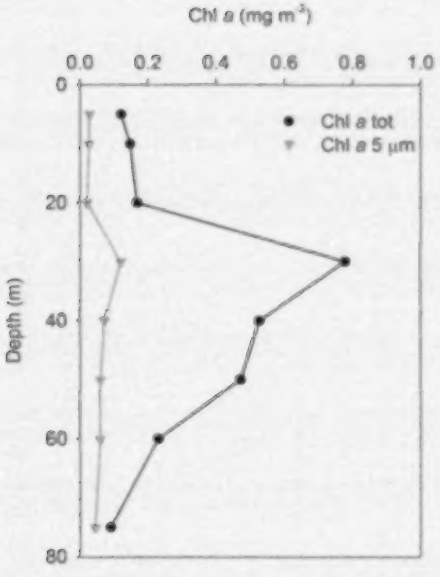


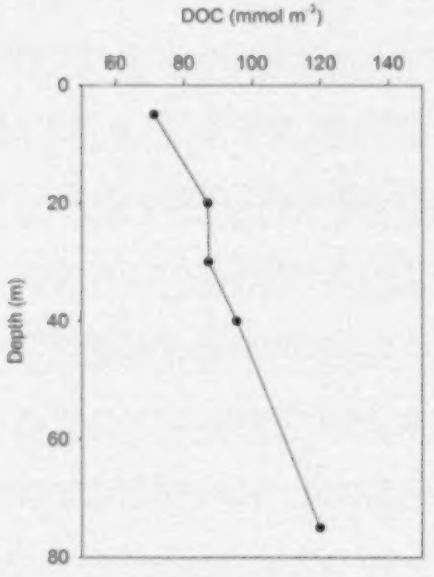


13/08/2013: Cast 26, Station ULU-02 (Off-shore shelf)

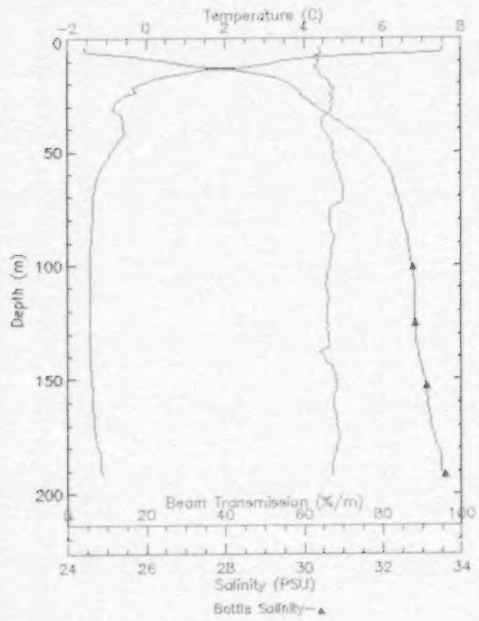


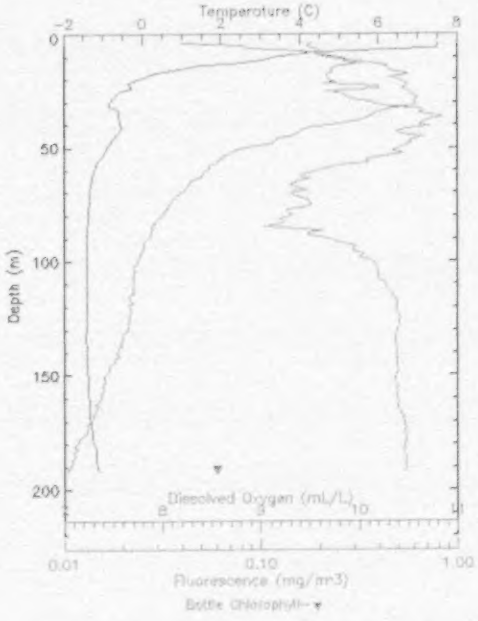


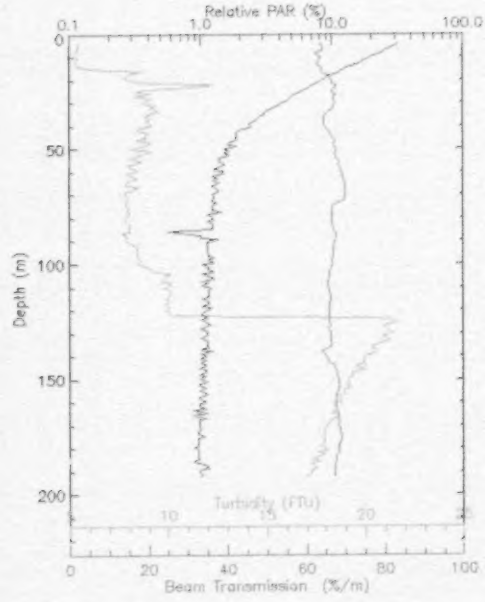




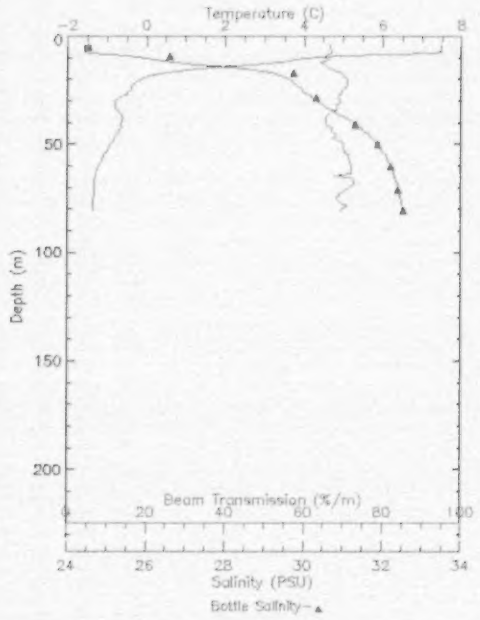
14/08/2013: Cast 27, Station ULU-03 (Off-shore shelf)

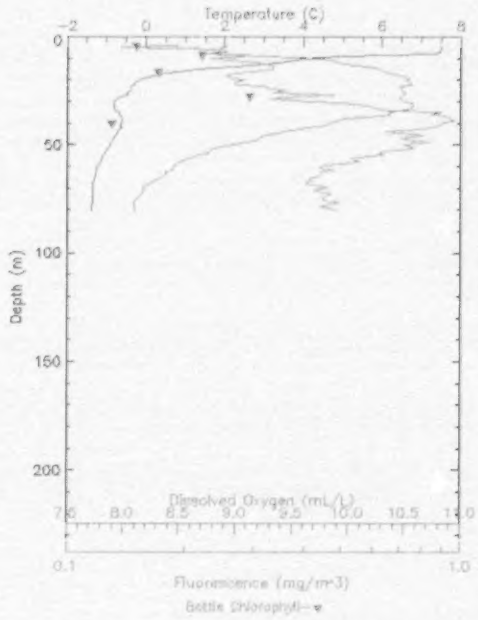


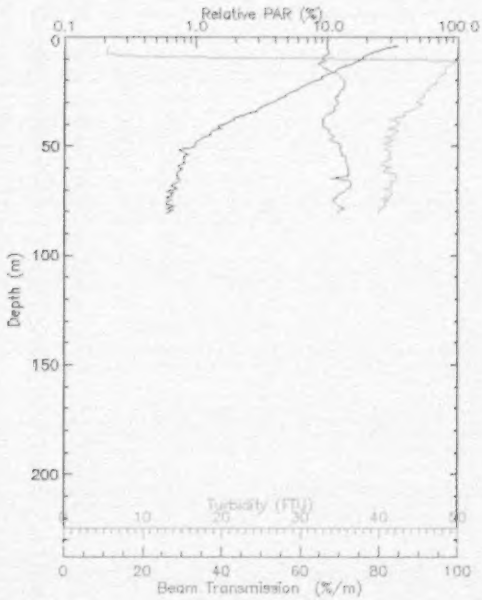




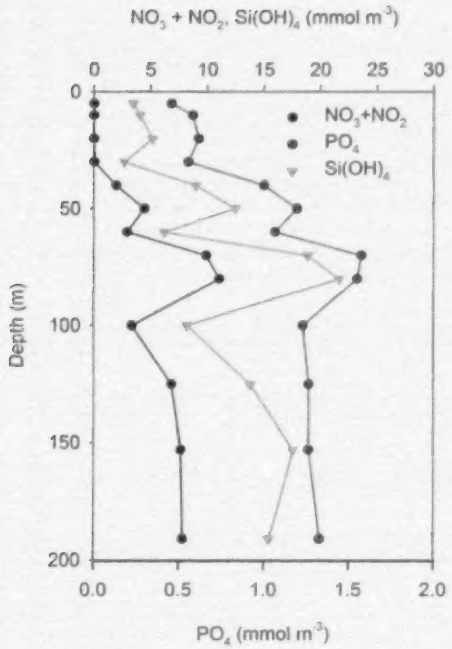
14/08/2013: Cast 28, Station ULU-03 (Off-shore shelf)

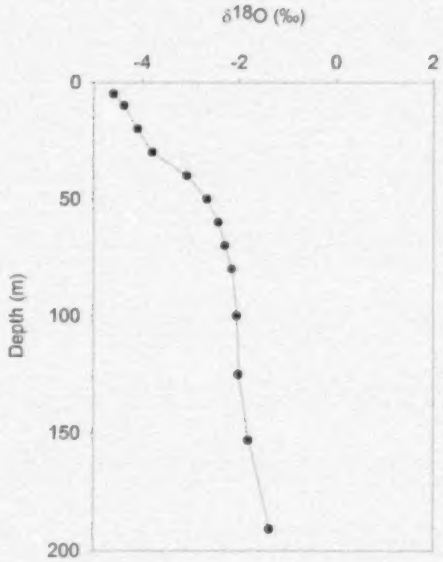


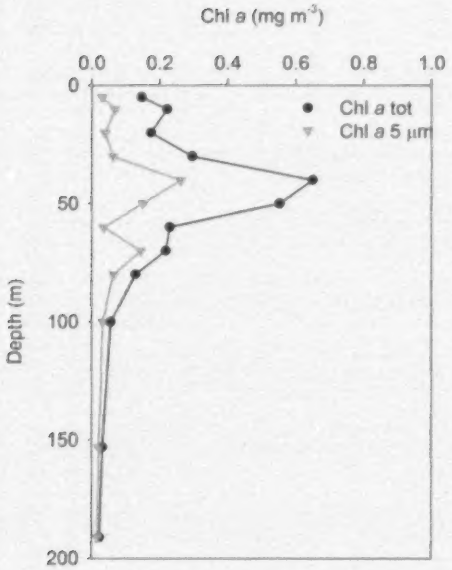


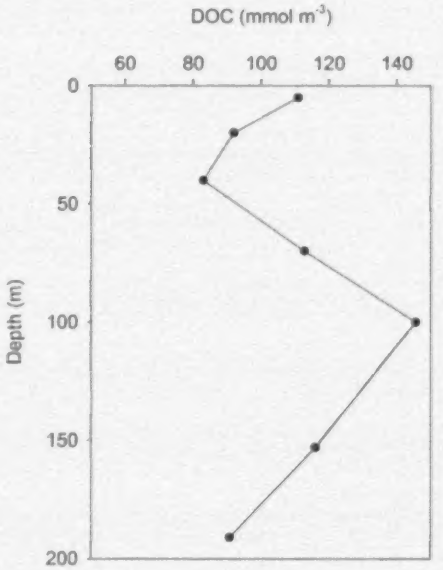


14/08/2013: Cast 27/28, Station ULU-03 (Off-shore shelf)

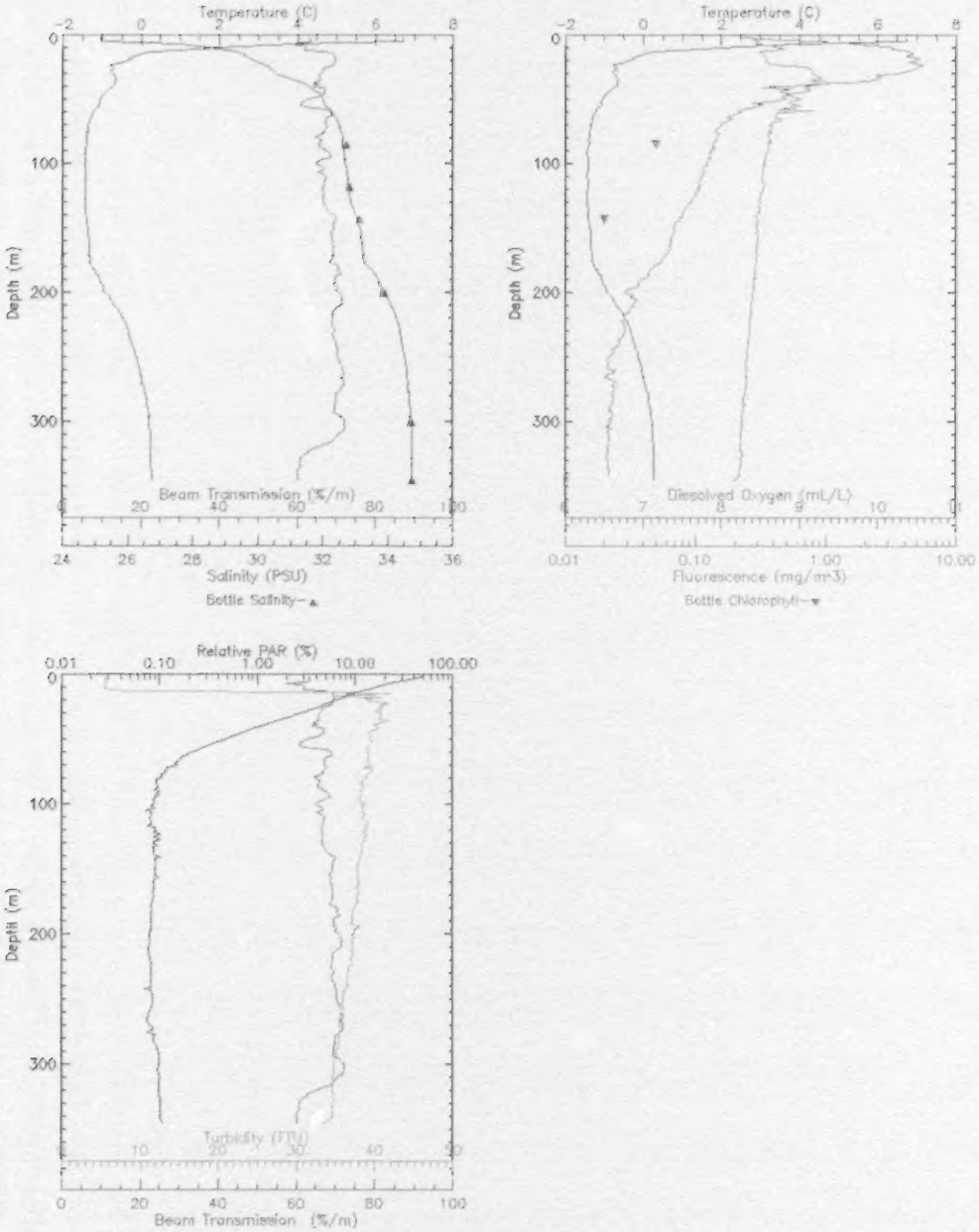




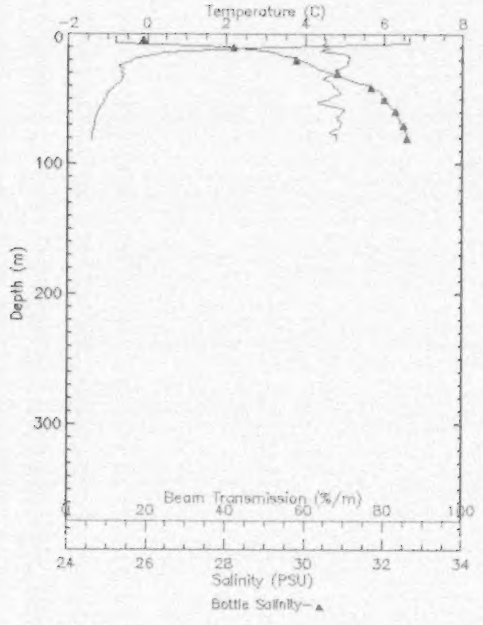


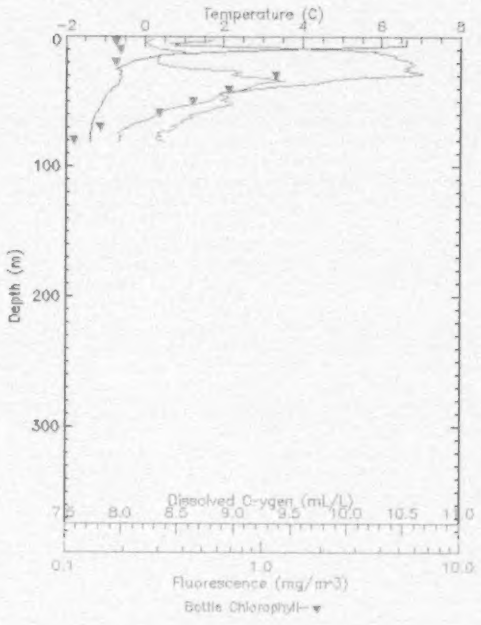


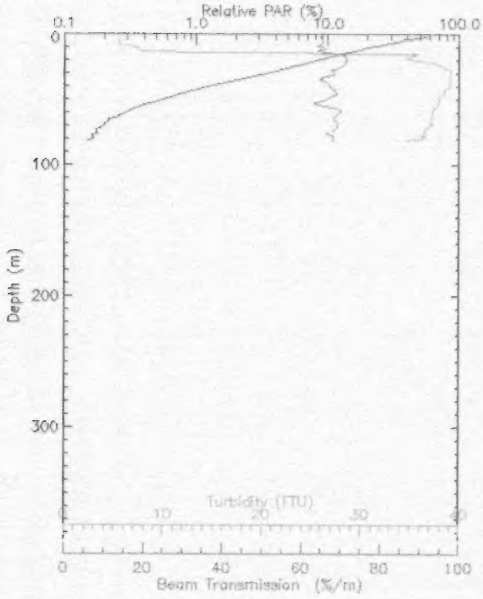
14/08/2013: Cast 29, Station ULU-04 (Upper slope)



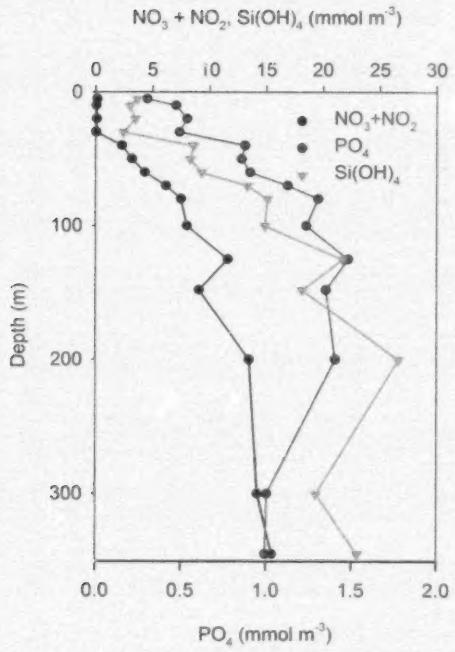
14/08/2013: Cast 30, Station ULU-04 (Upper slope)

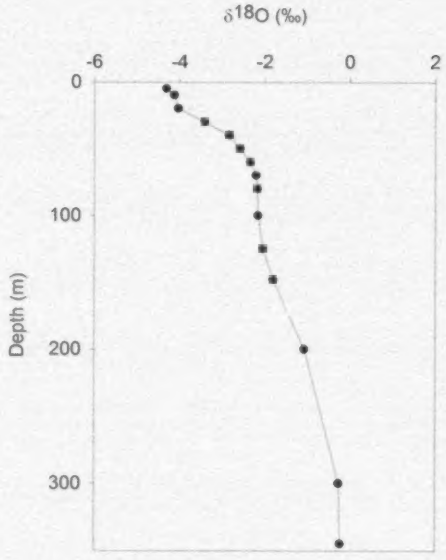


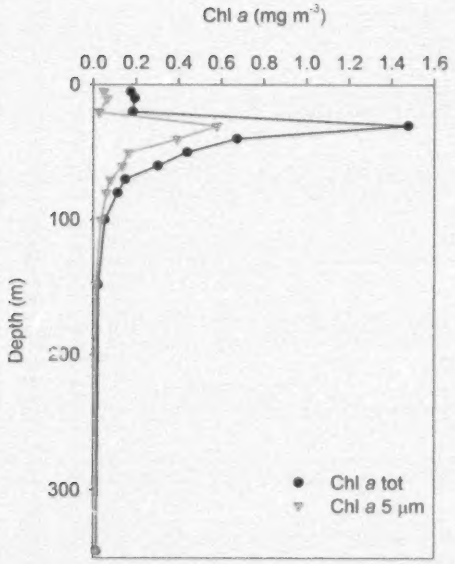


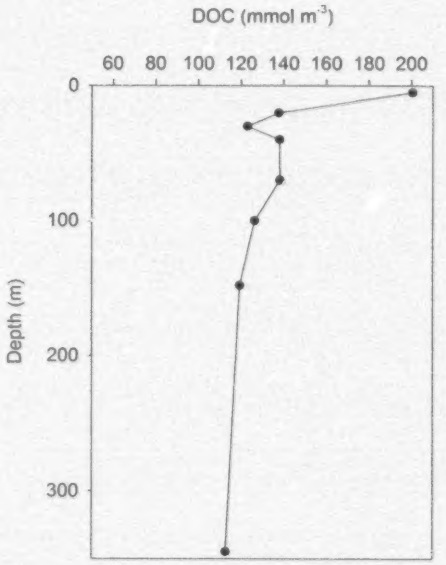


14/08/2013: Cast 29/30, Station ULU-04 (Upper slope)

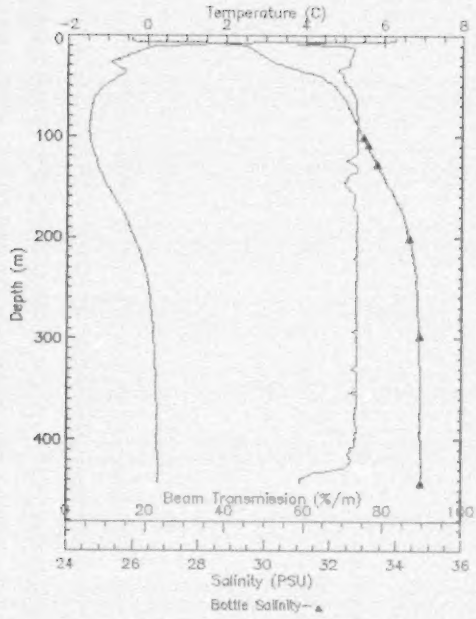


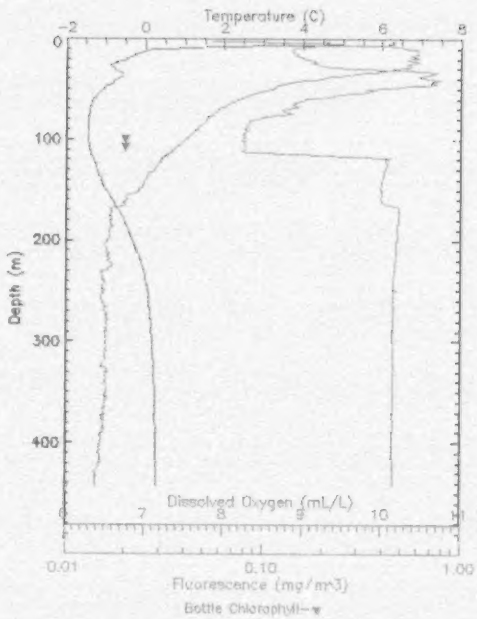


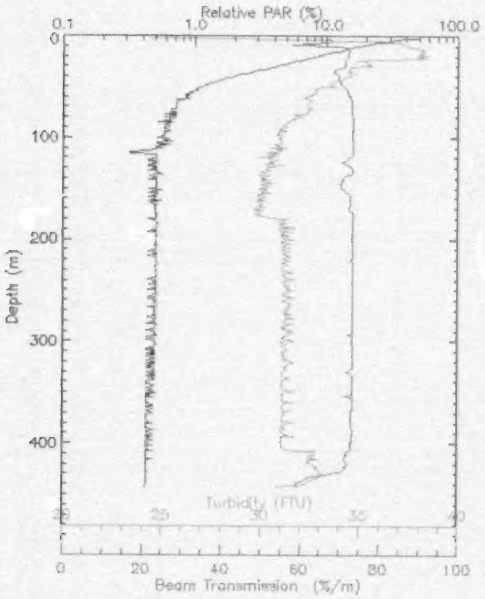




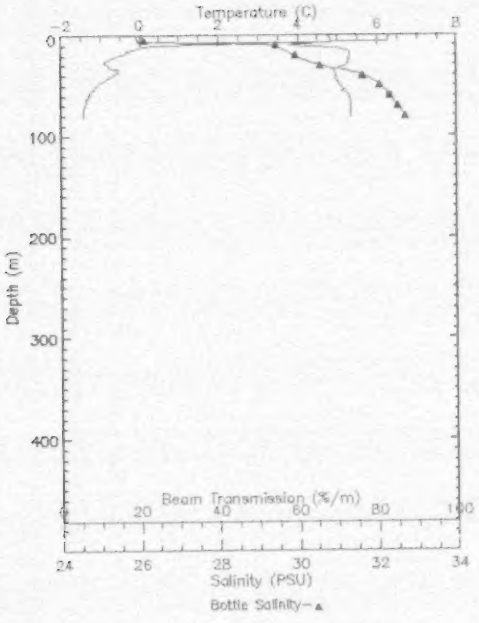
15/08/2013: Cast 31, Station ULU-05 (Upper slope)

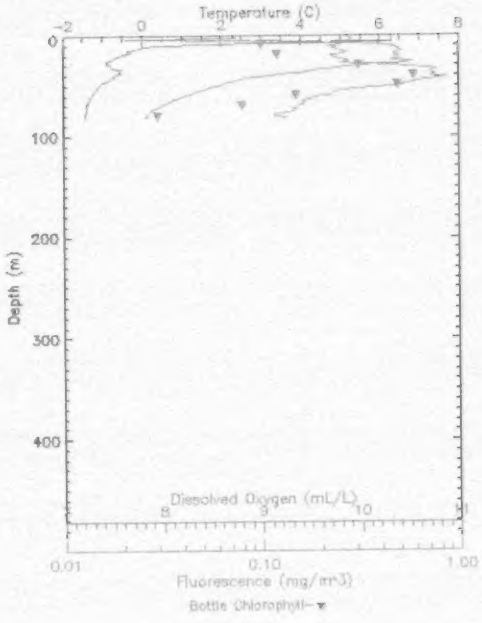


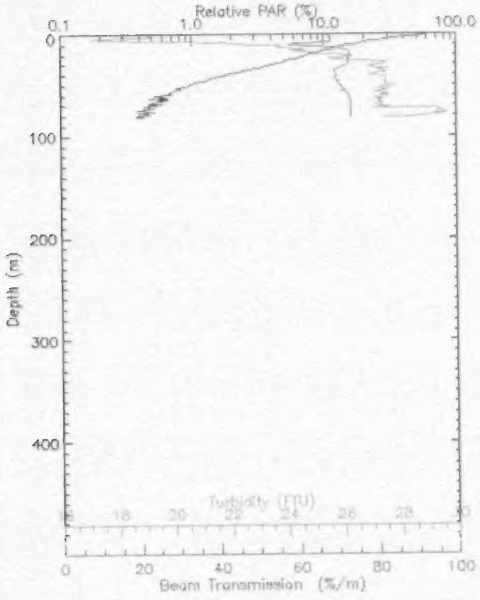




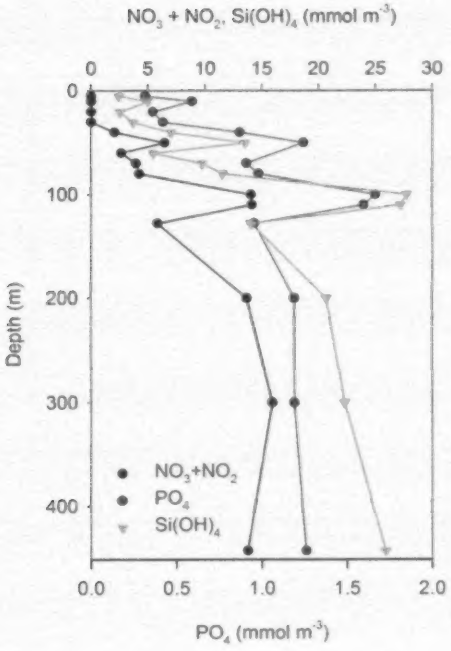
15/08/2013: Cast 32, Station ULU-05 (Upper slope)

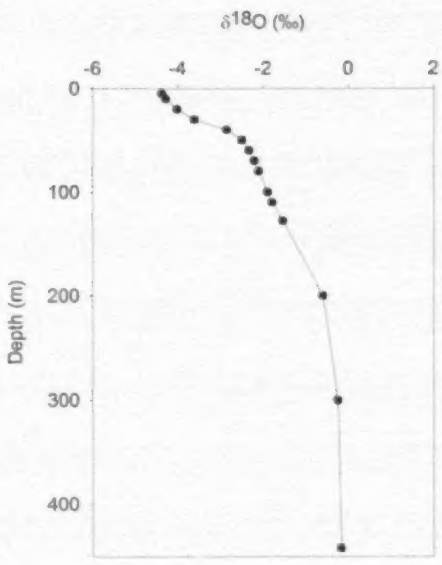


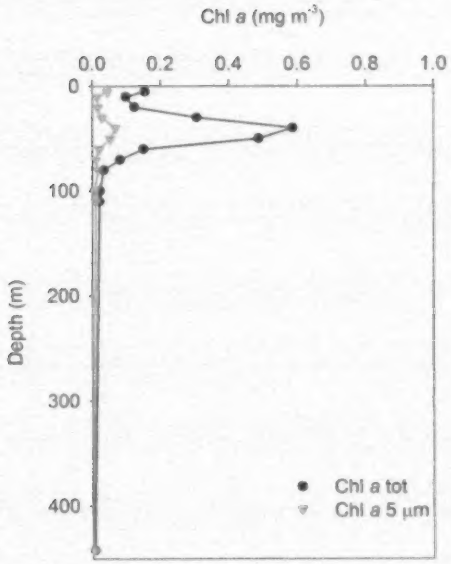


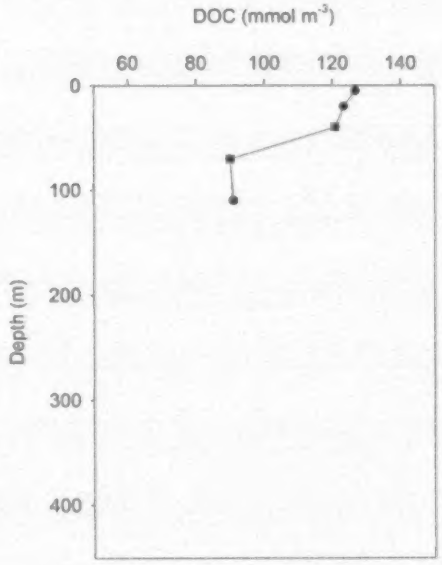


15/08/2013: Cast 31/32, Station ULU-05 (Upper slope)

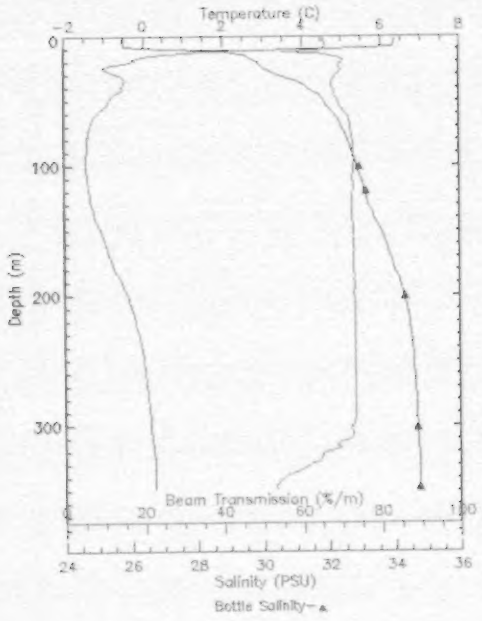


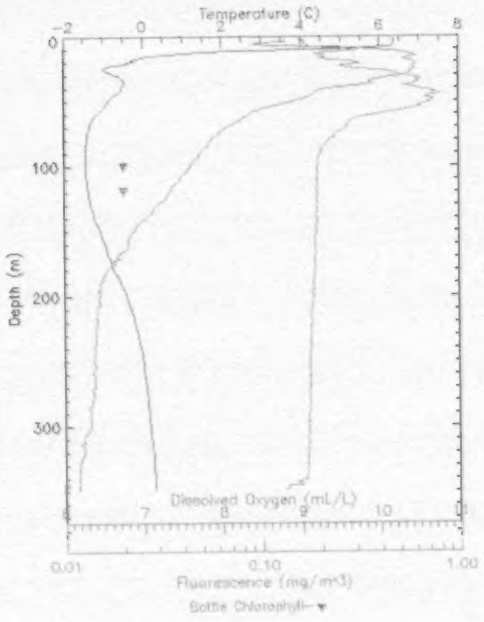


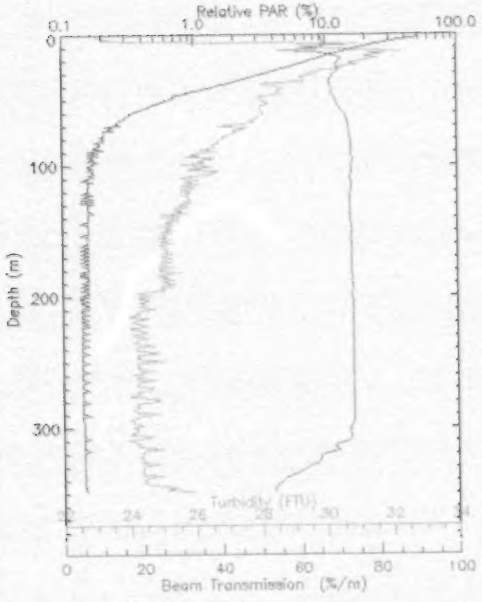




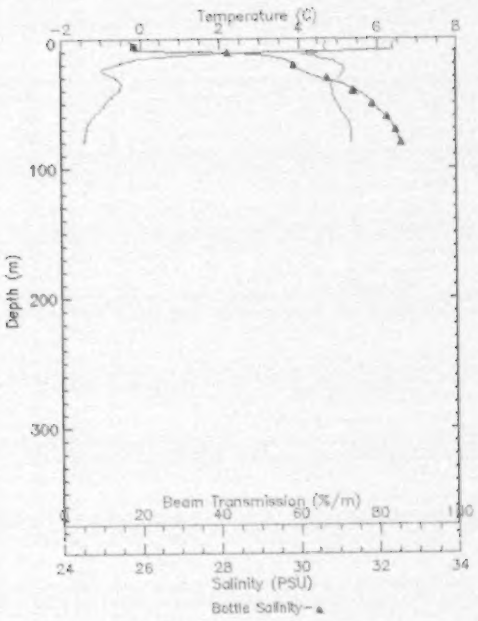
15/08/2013: Cast 33, Station ULU-06 (Upper slope)

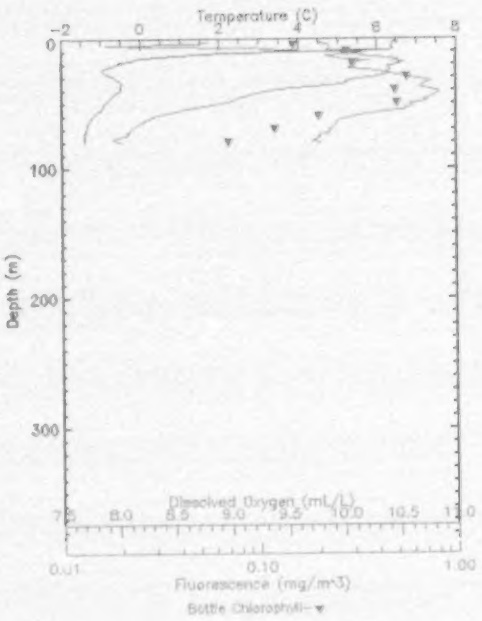


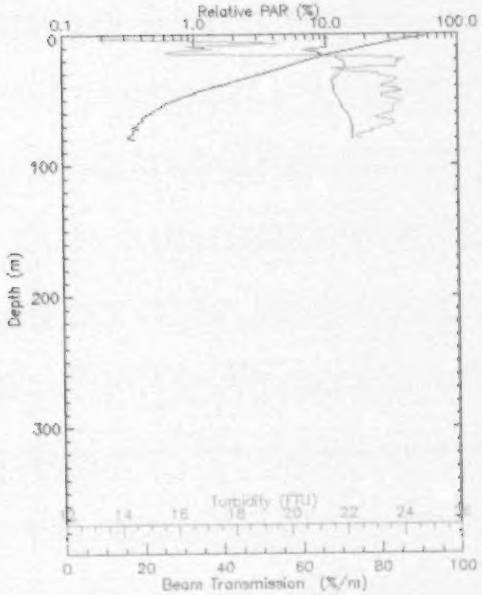




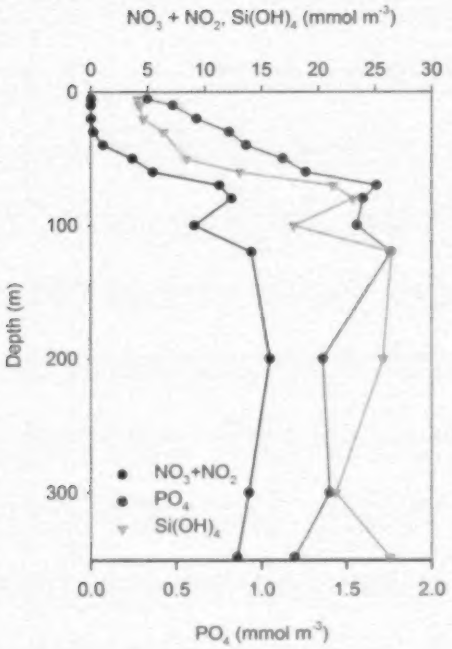
15/08/2013: Cast 34, Station ULU-06 (Upper slope)

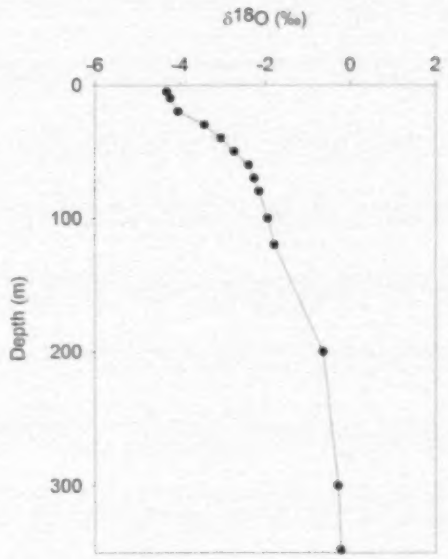


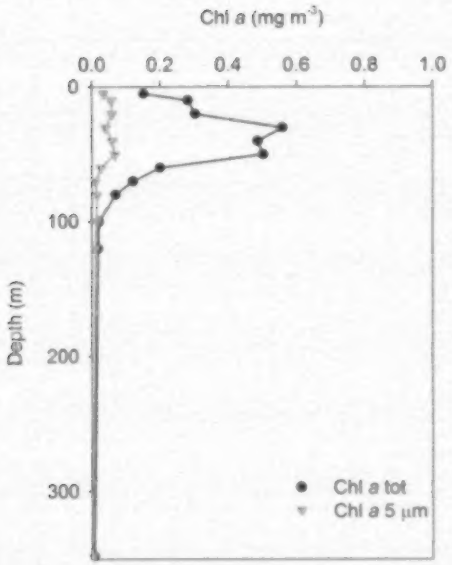


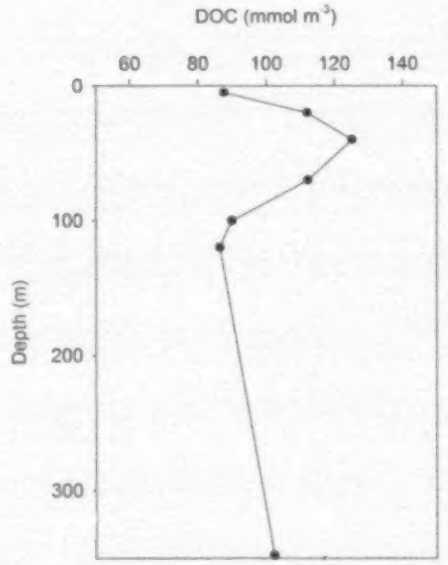


15/08/2013: Cast 33/34, Station ULU-06 (Upper slope)

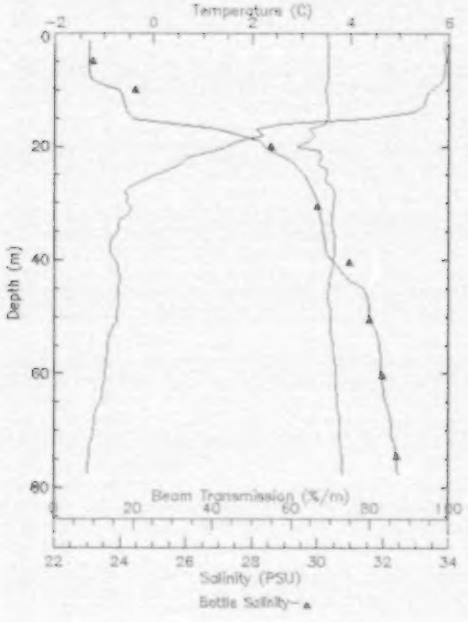


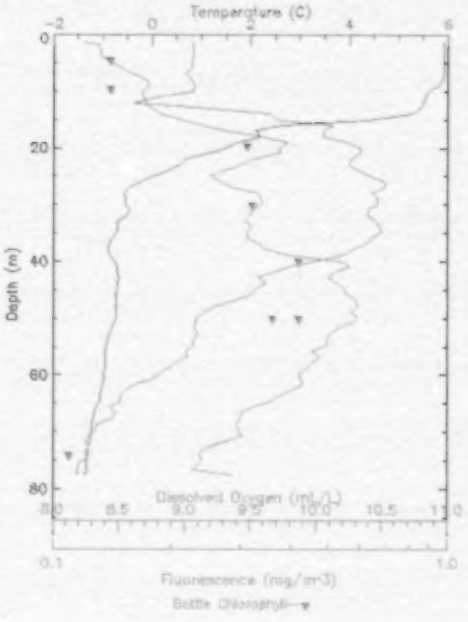


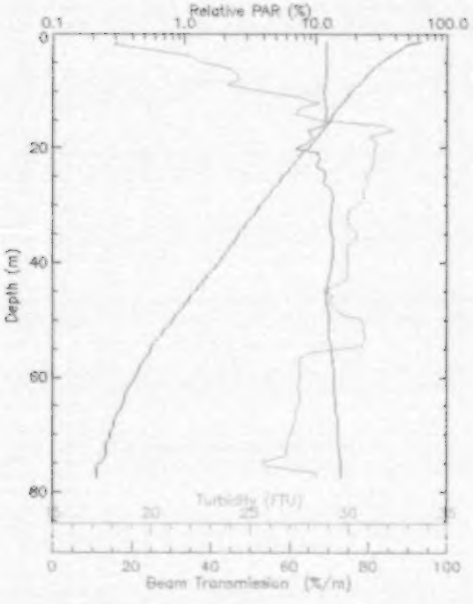




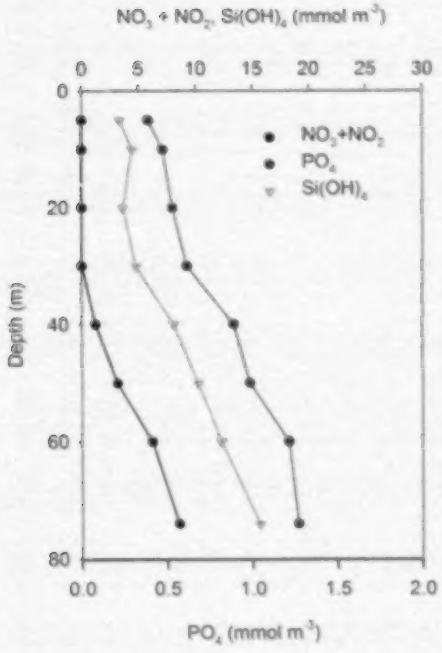
16/08/2013: Cast 35, Station ULU-07 (Off-shore shelf)

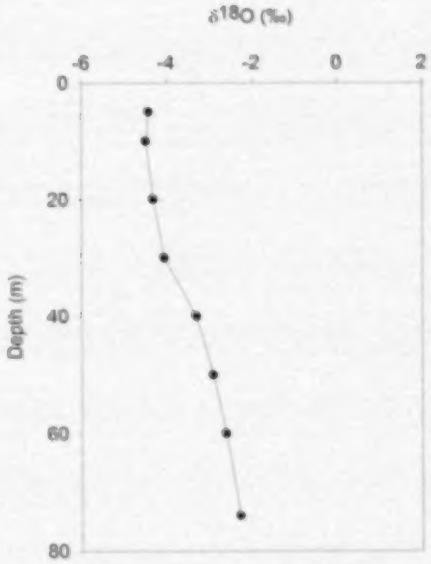


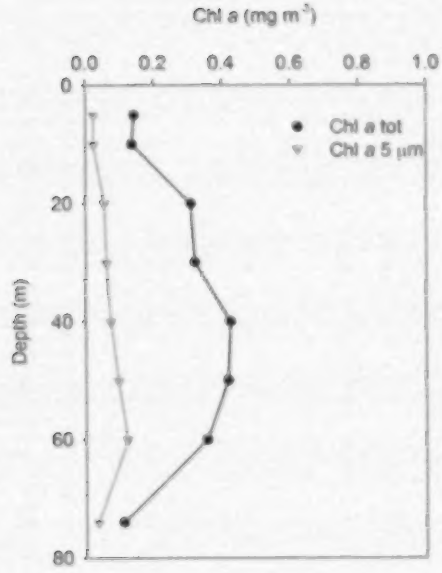


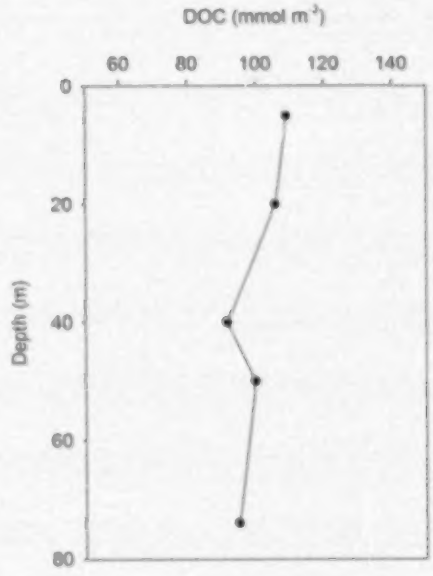


16/08/2013: Cast 35, Station ULU-07 (Off-shore shelf)

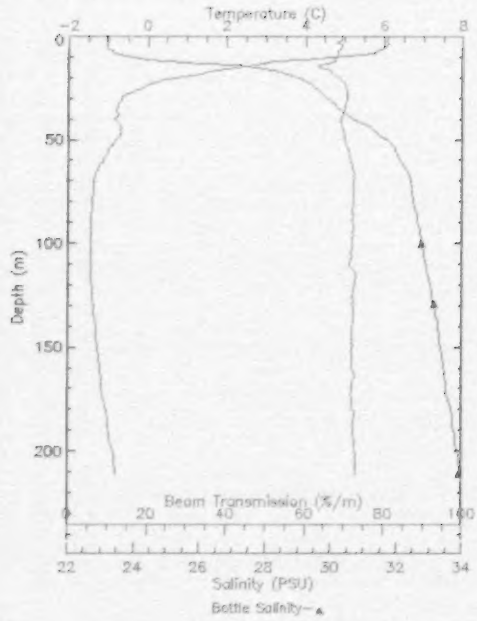


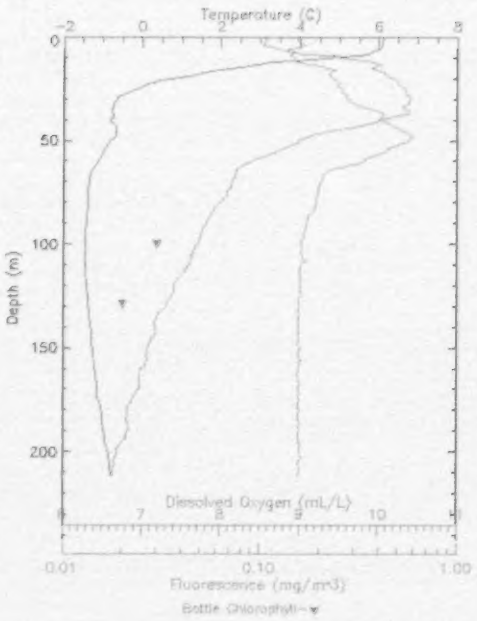


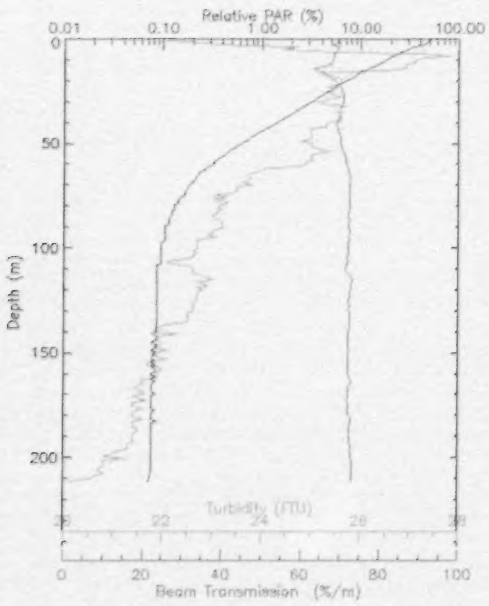




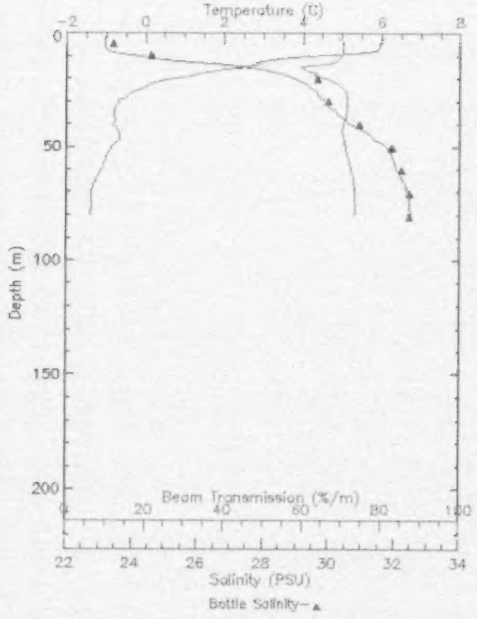
16/08/2013: Cast 36, Station ULU-08 (Upper slope)

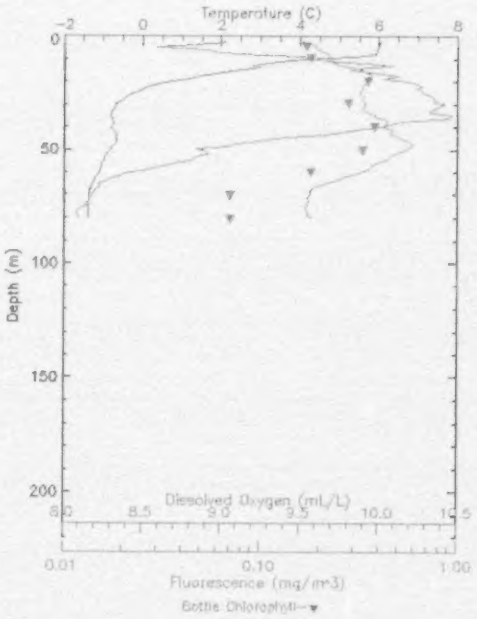


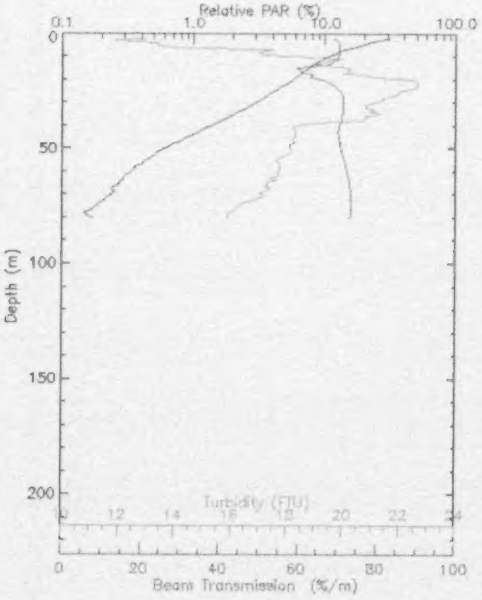




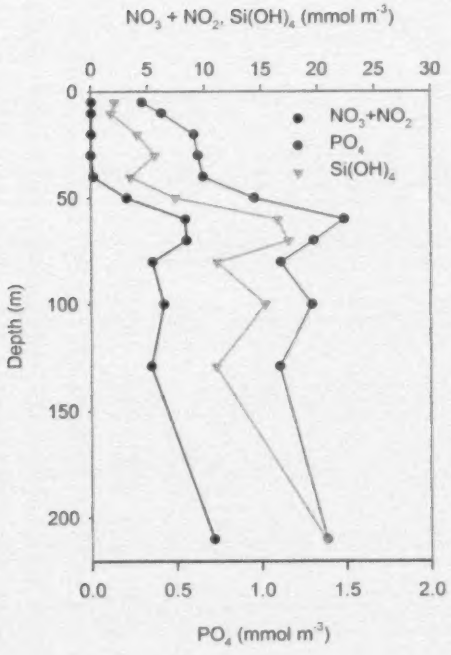
16/08/2013: Cast 37, Station ULU-08 (Upper slope)

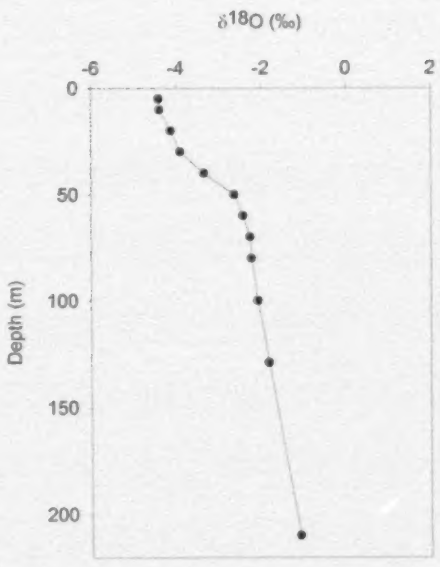


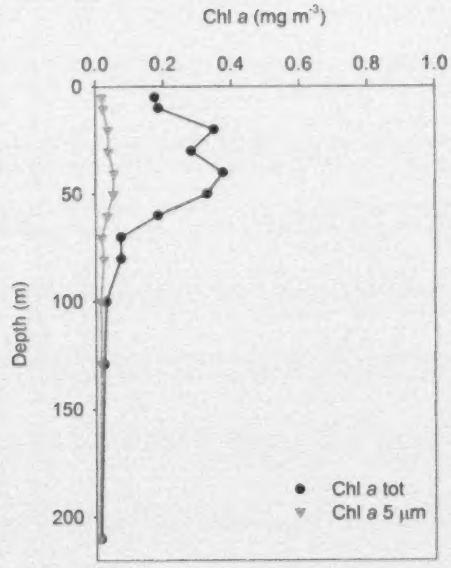


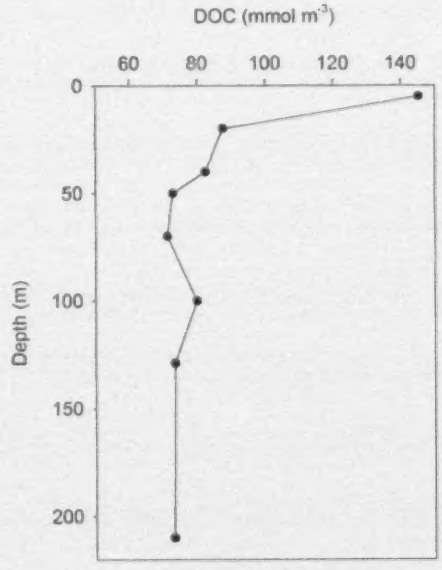


16/08/2013: Cast 36/37, Station ULU-08 (Upper slope)

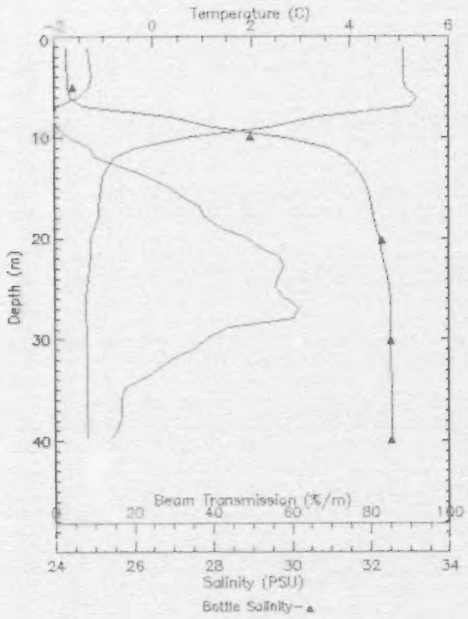


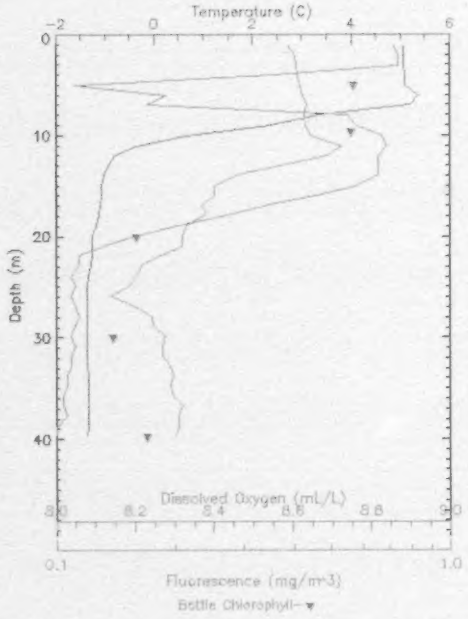


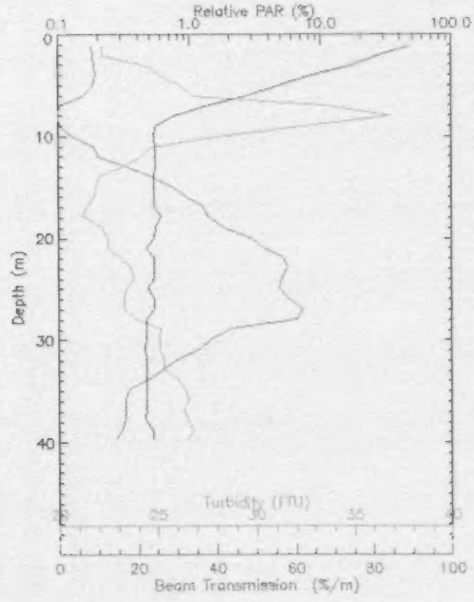




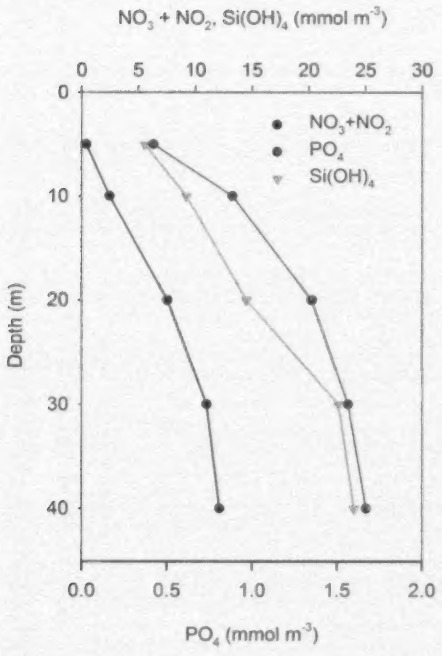
20/08/2013: Cast 38, Station CBH-01 (Near-shore shelf)

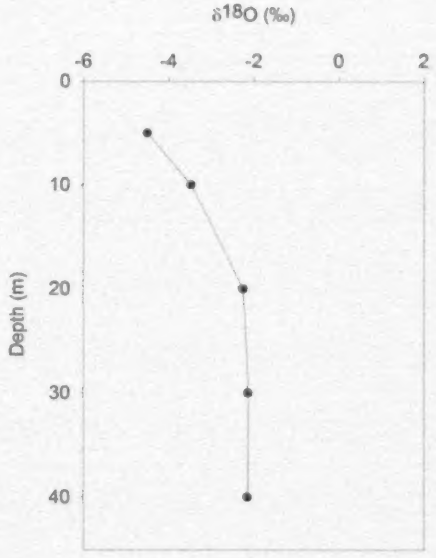


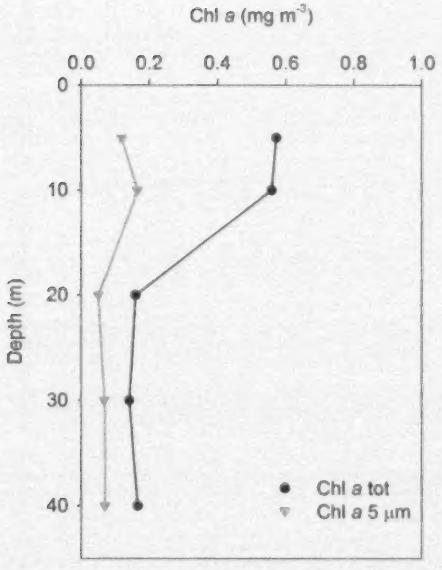


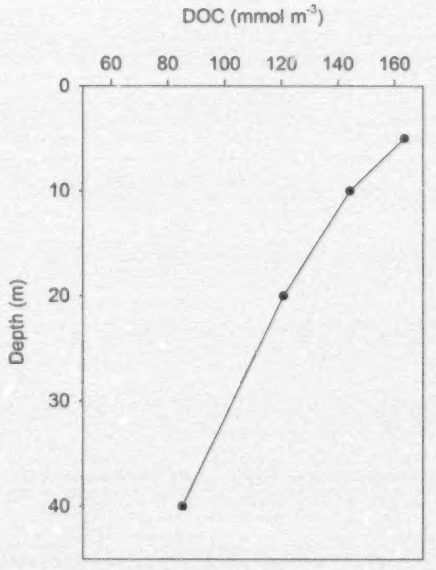


20/08/2013: Cast 38, Station CBH-01 (Near-shore shelf)

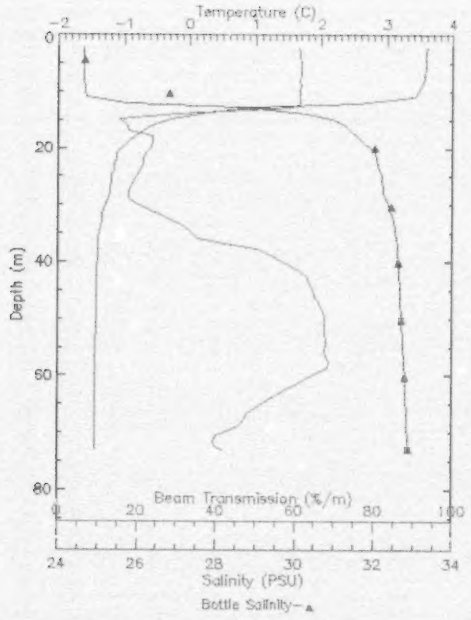


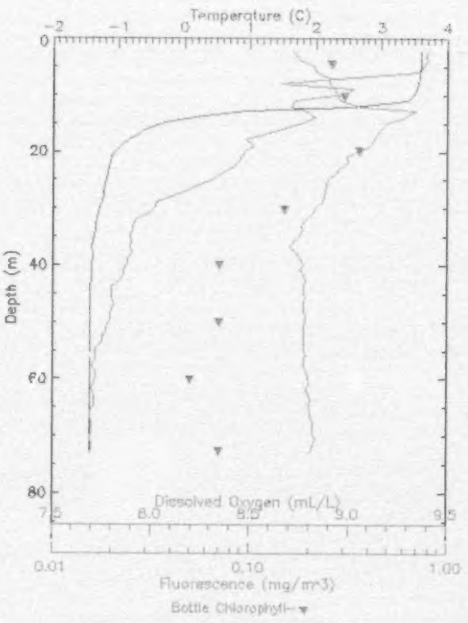


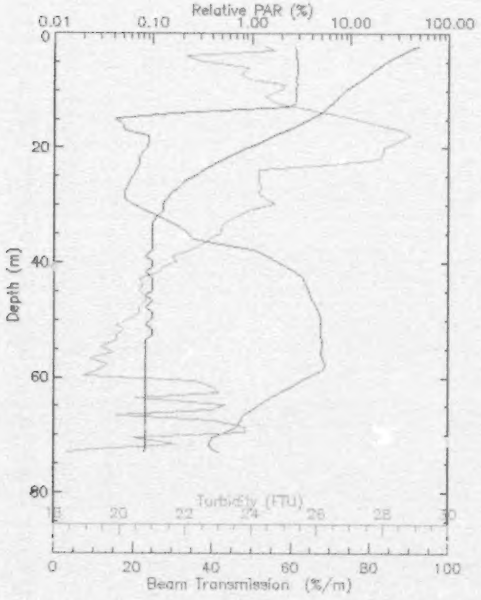




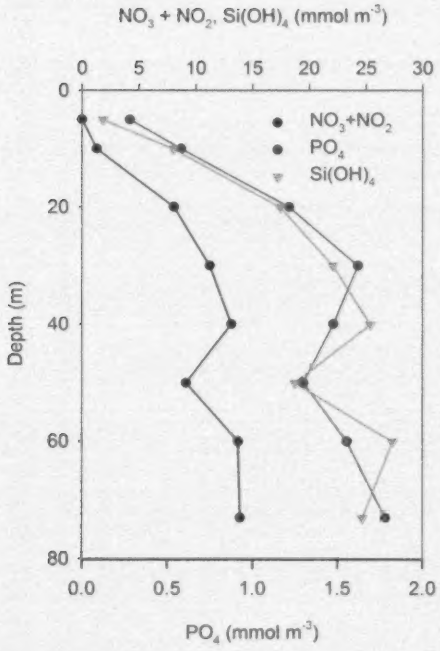
20/08/2013: Cast 39, Station CBH-02 (Off-shore shelf)

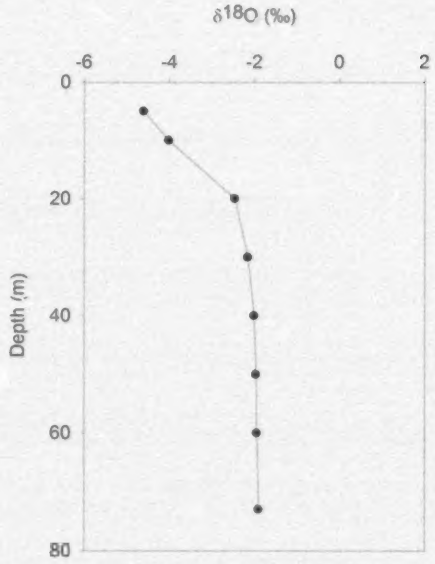


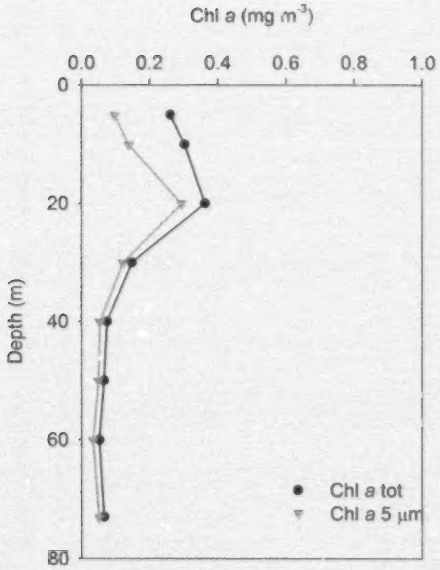


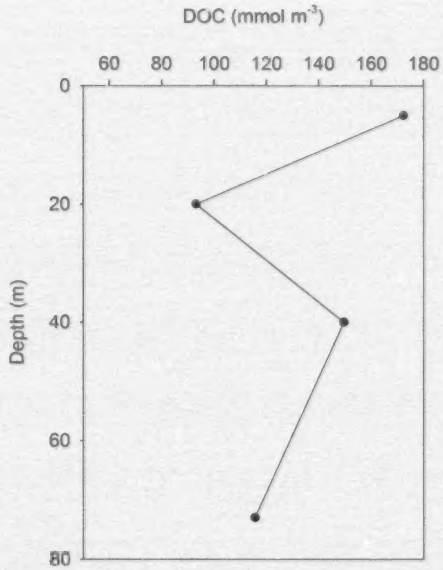


20/08/20*3: Cast 39, Station CBH-02 (Off-shore shelf)

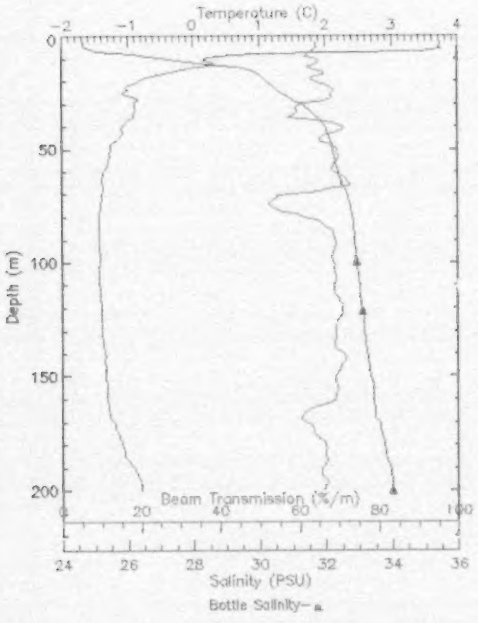


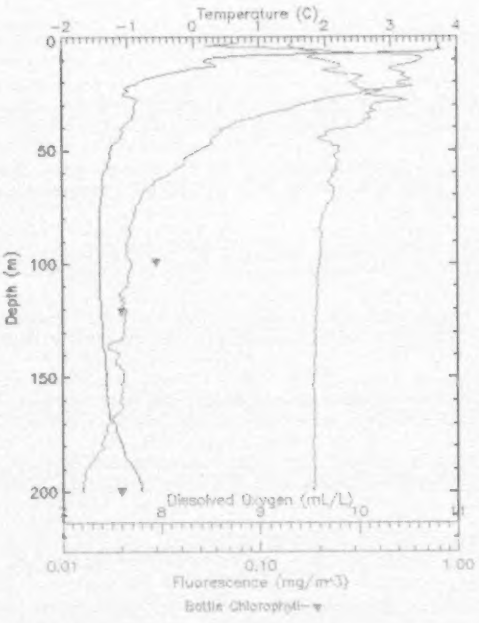


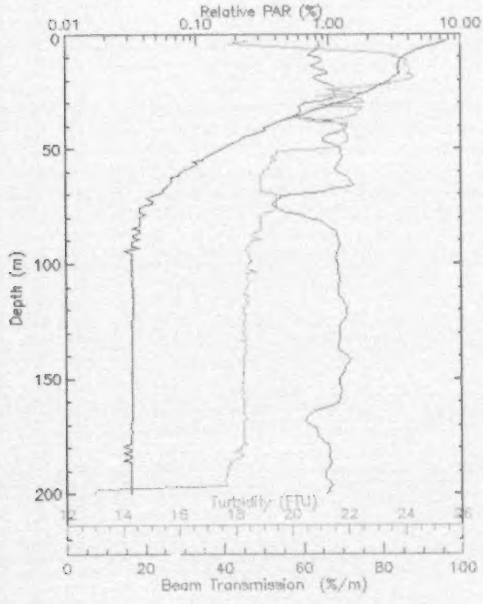




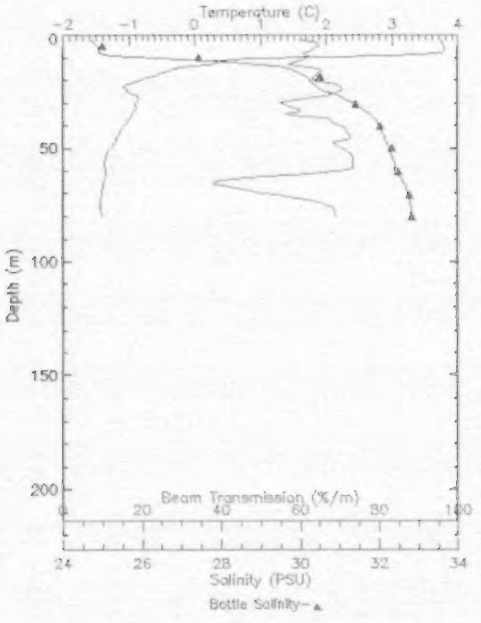
20/08/2013: Cast 40, Station CBH-03 (Off-shore shelf)

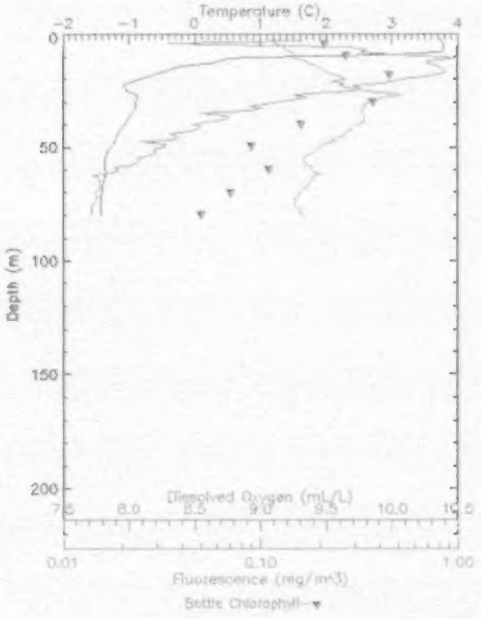


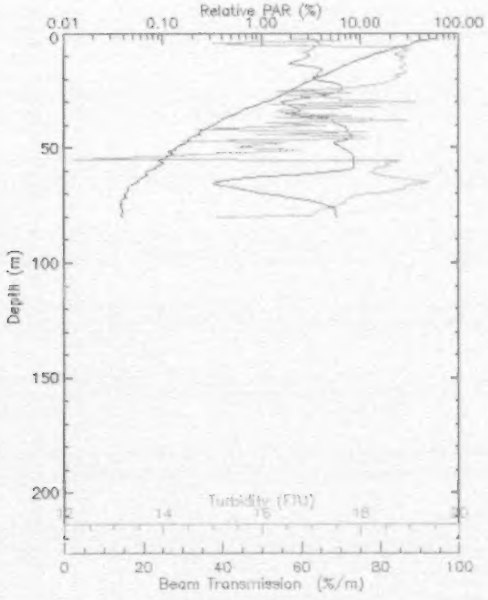




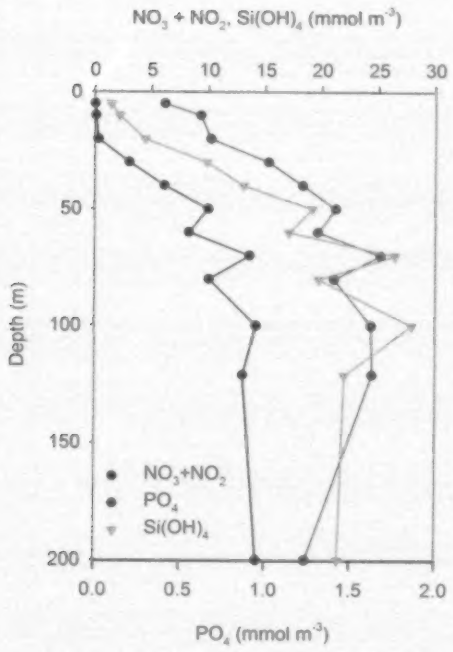
20/08/2013: Cast 41, Station CBH-03 (Off-shore shelf)

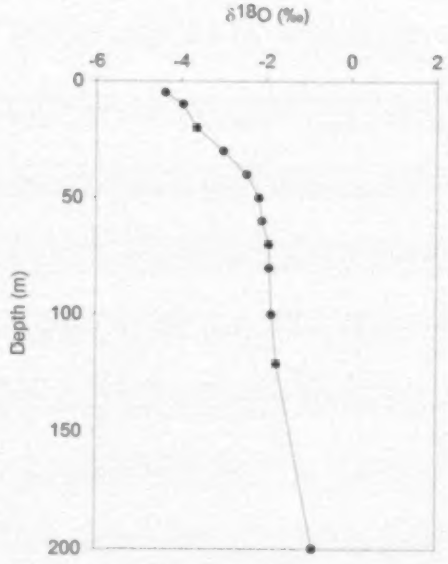


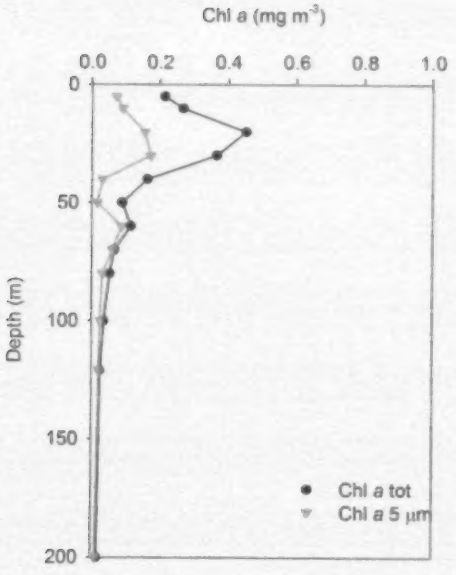


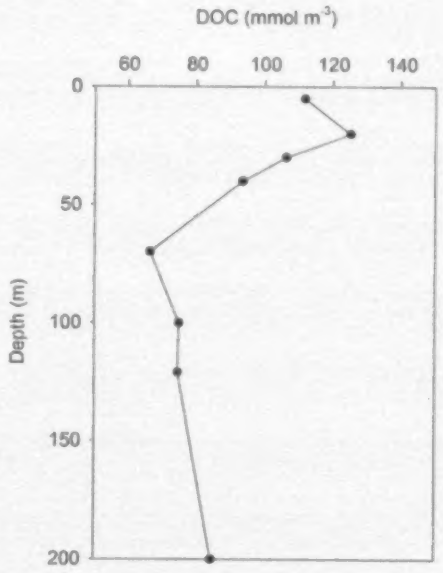


20/08/2013: Cast 40/41, Station CBH-03 (Off-shore shelf)

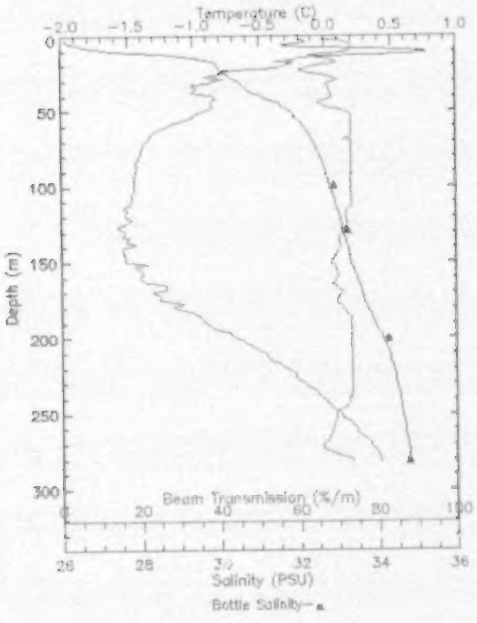


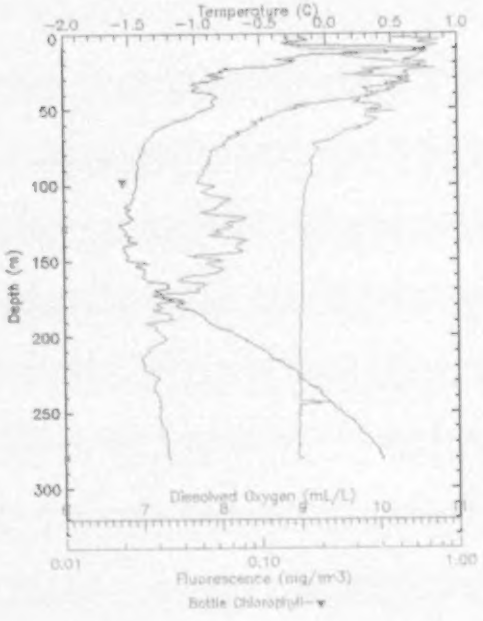


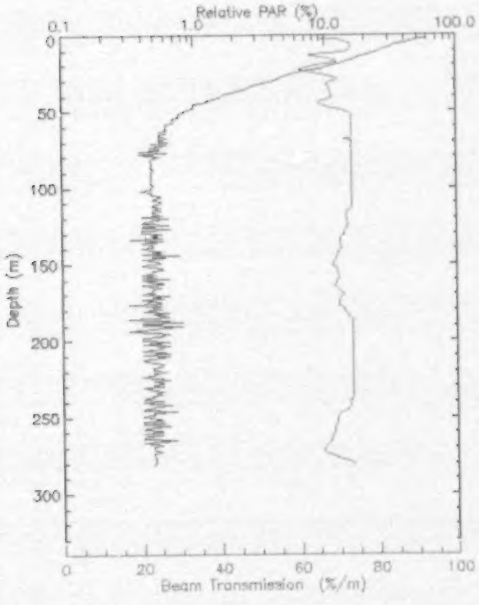




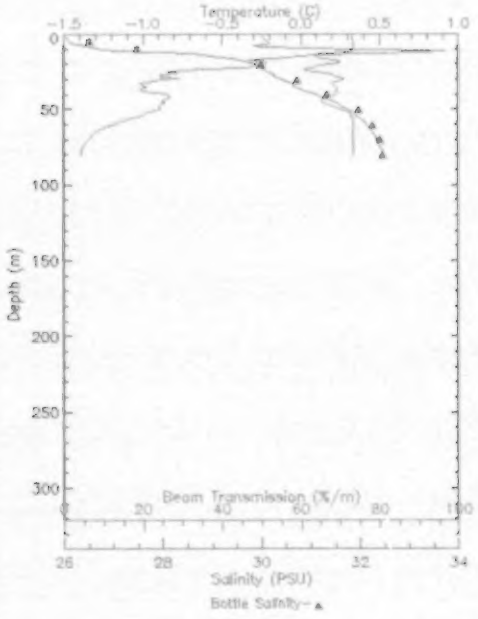
21/08/2013: Cast 42, Station CBH-04 (Upper slope)

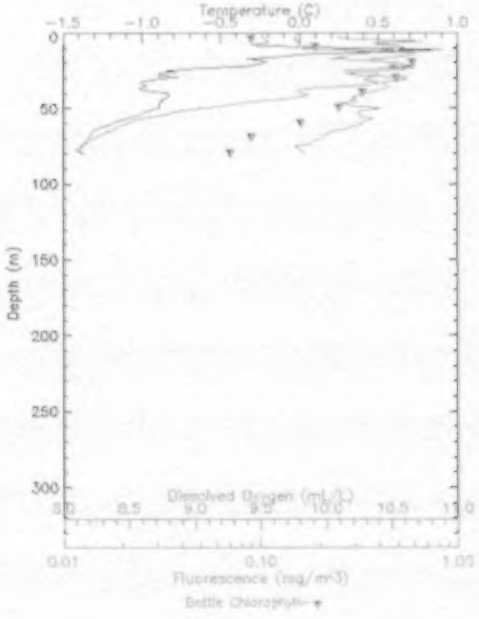


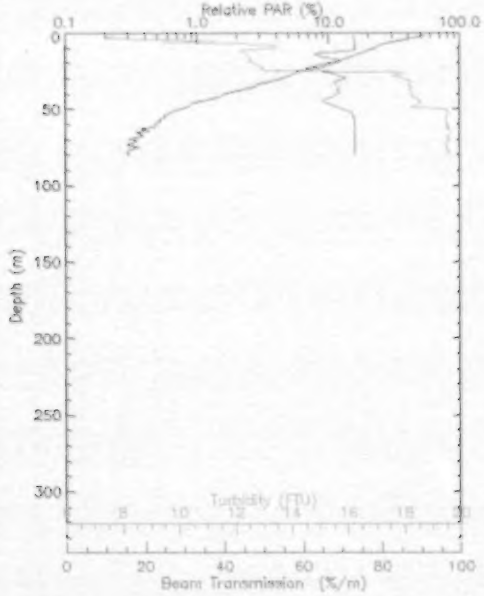




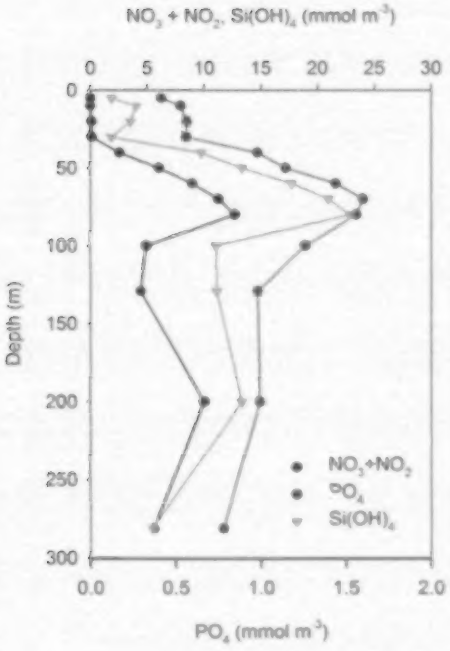
21/08/2013: Cast 43, Station CBH-04 (Upper slope)

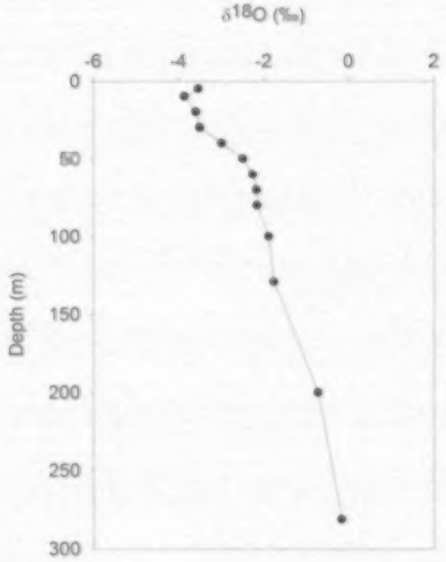


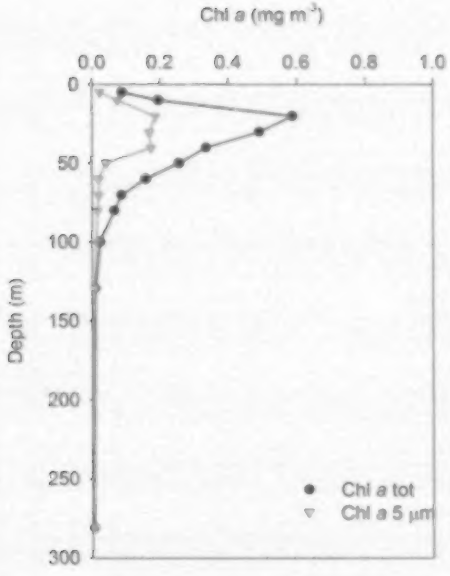


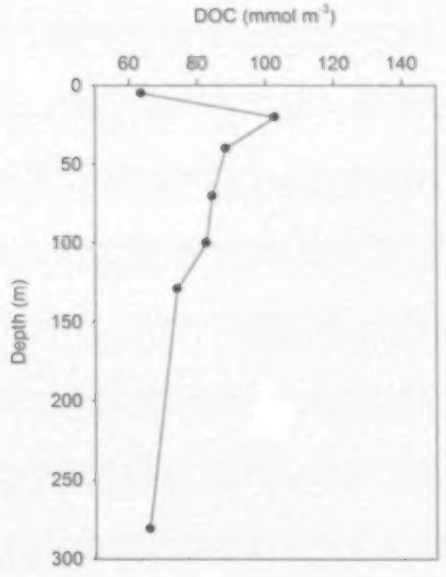


21/08/2013: Cast 42/43, Station CBH-04 (Upper slope)

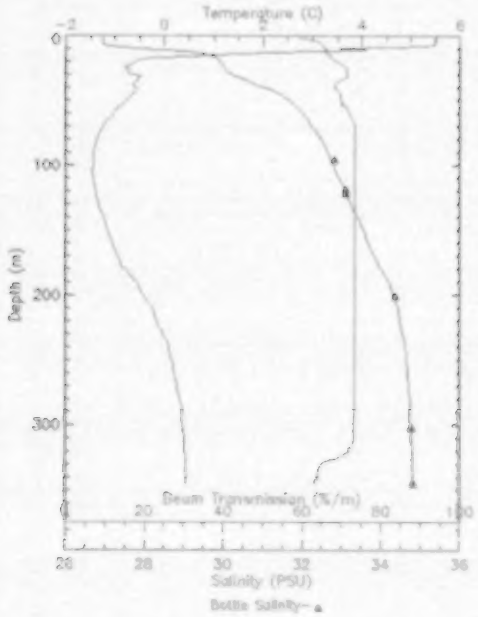


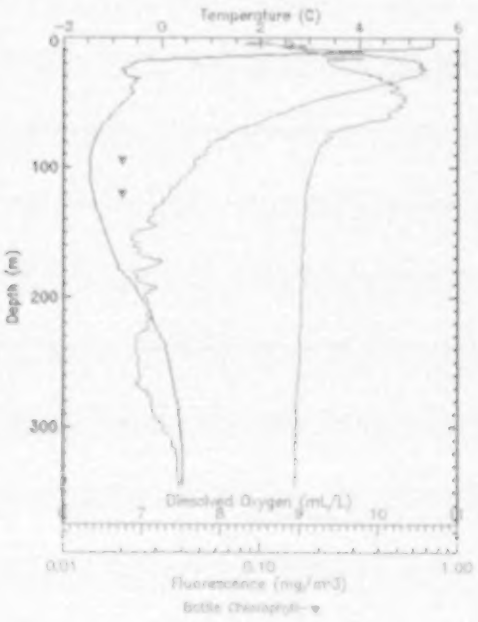


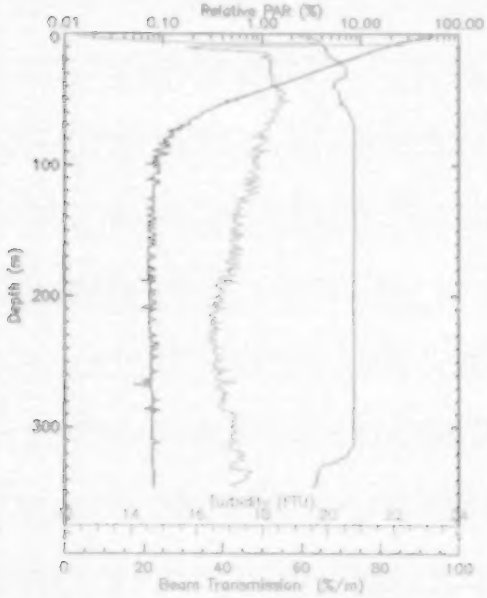




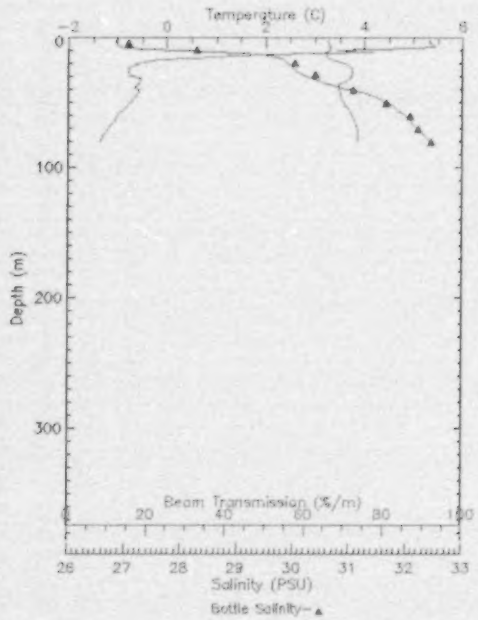
21/08/2013: Cast 44, Station CBH-05 (Upper slope)

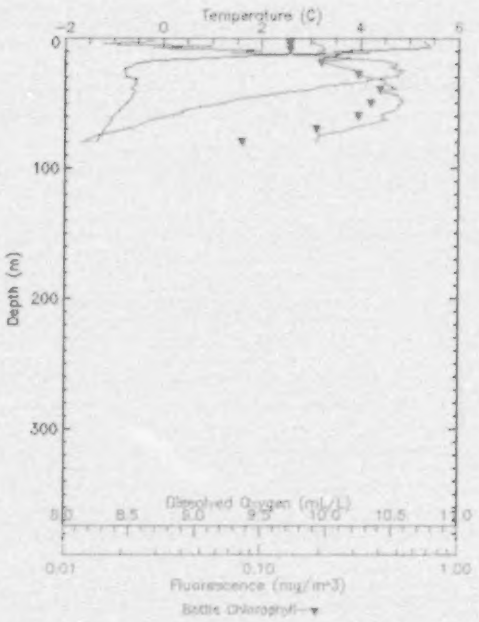


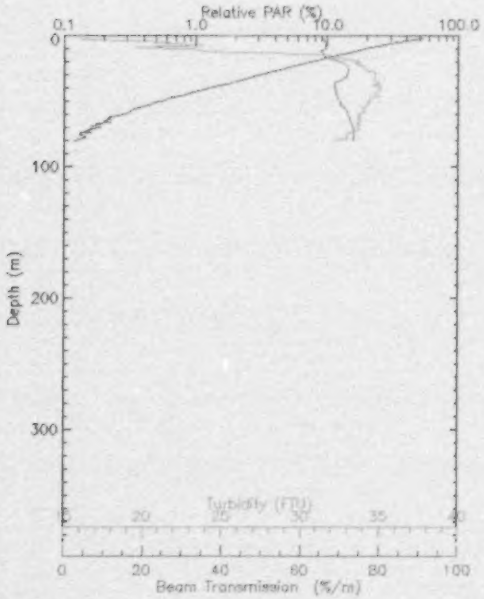




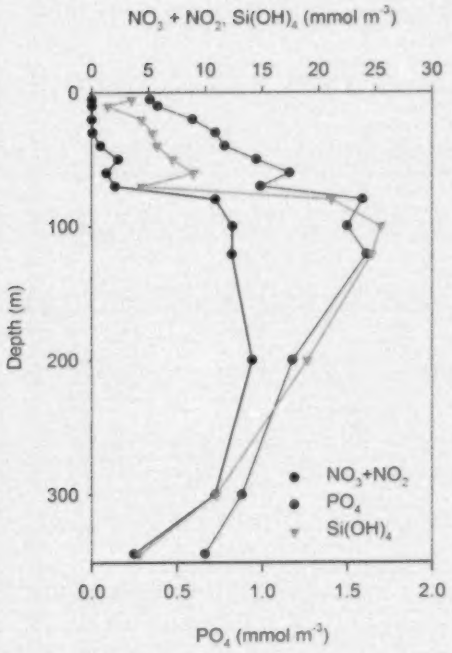
21/08/2013: Cast 45, Station CBH-05 (Upper slope)

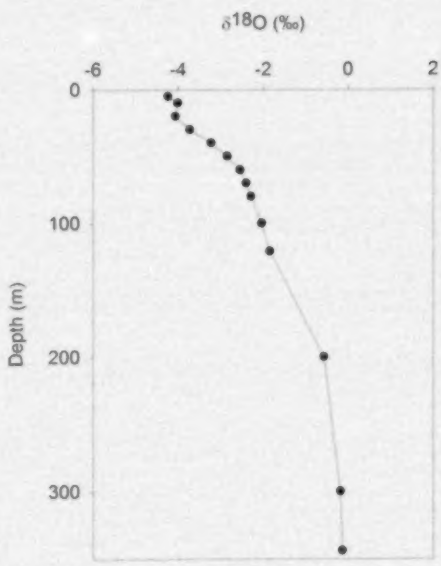


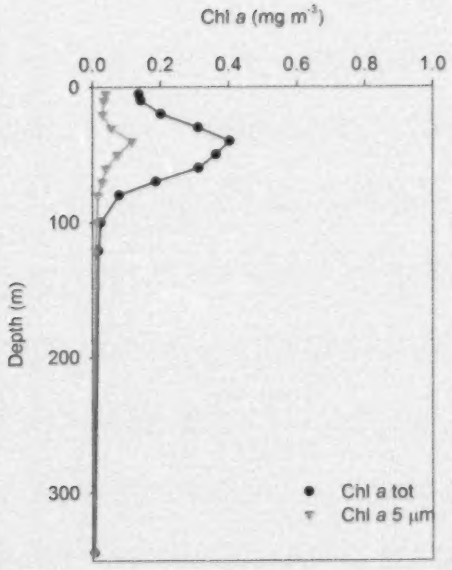


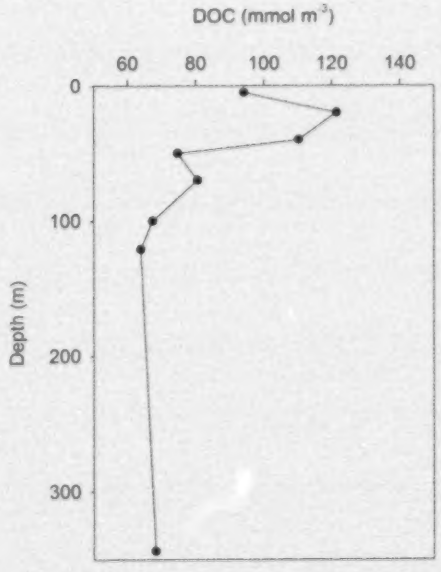


21/08/2013: Cast 44/45, Station CBH-05 (Upper slope)

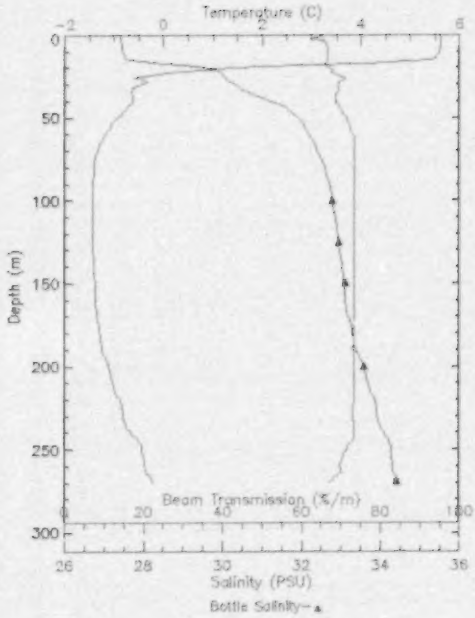


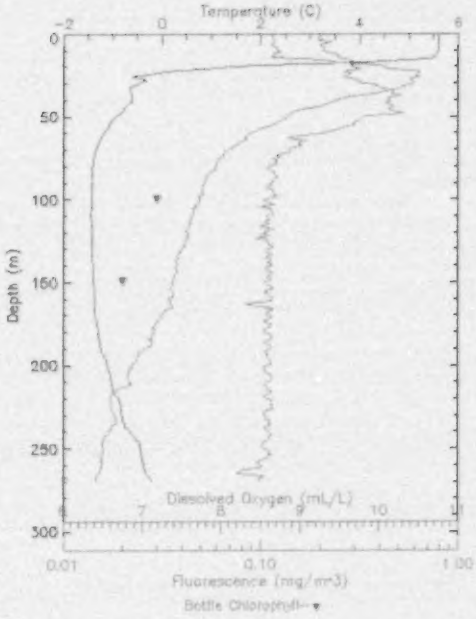


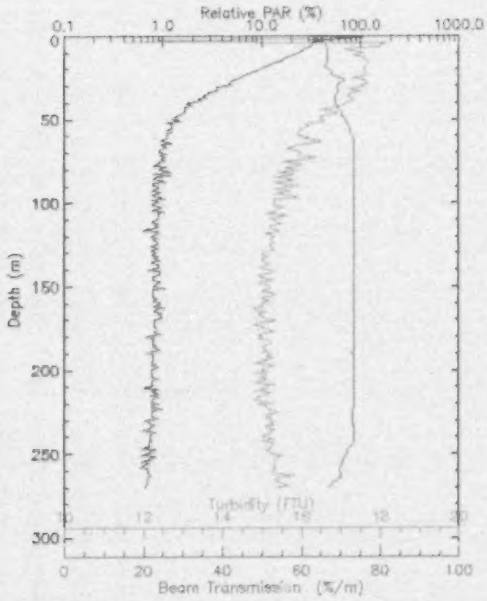




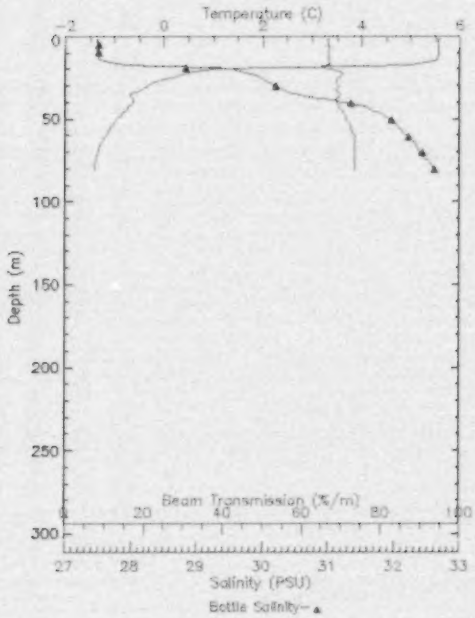
22/08/2013: Cast 46, Station CBH-06 (Upper slope)

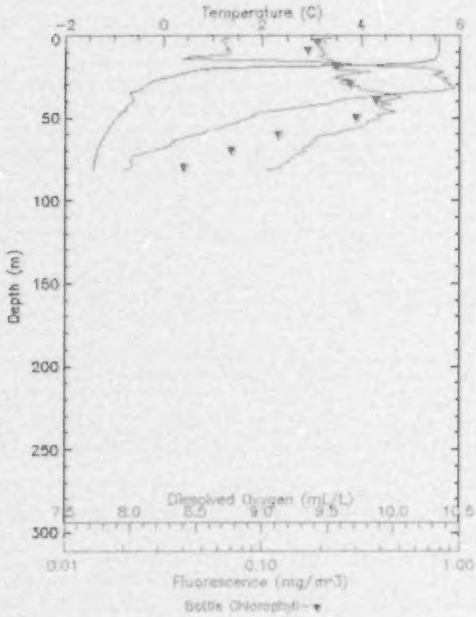


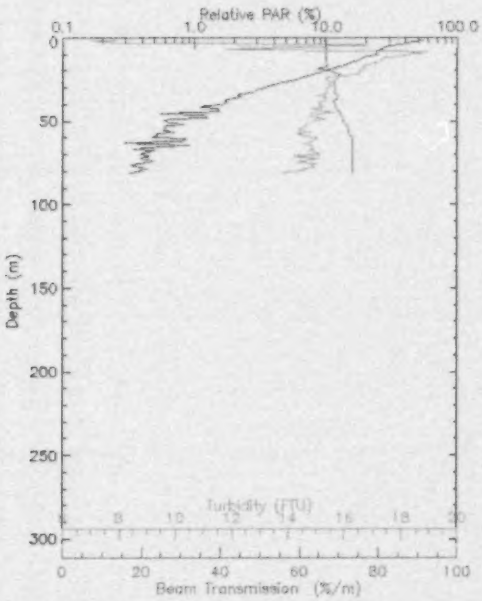




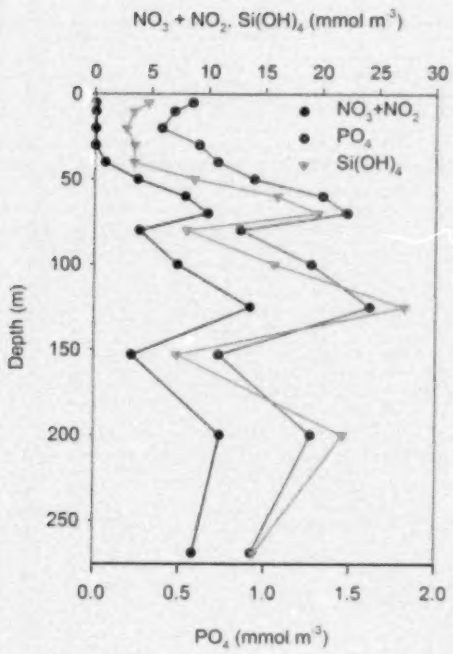
22/08/2013: Cast 47, Station CBH-06 (Upper slope)

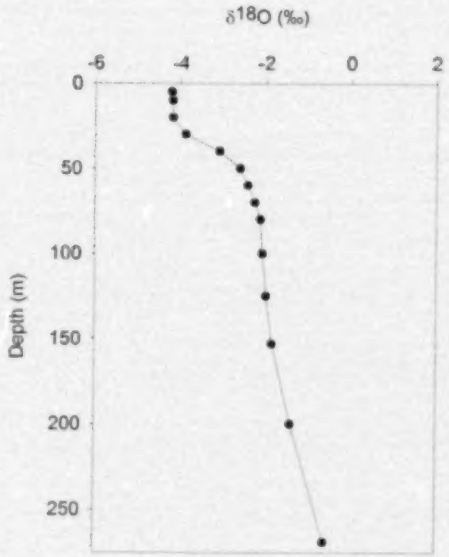


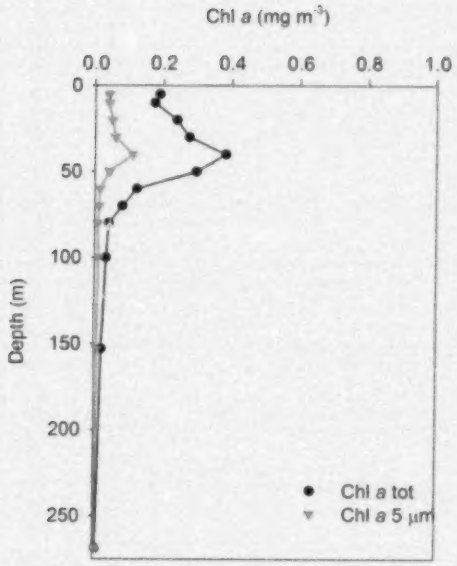


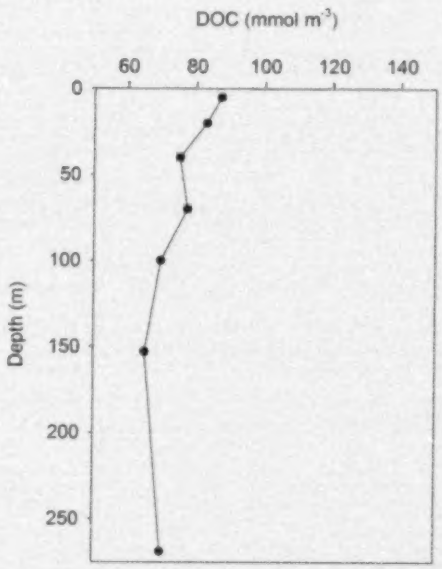


22/08/2013: Cast 46/47, Station CBH-06 (Upper slope)

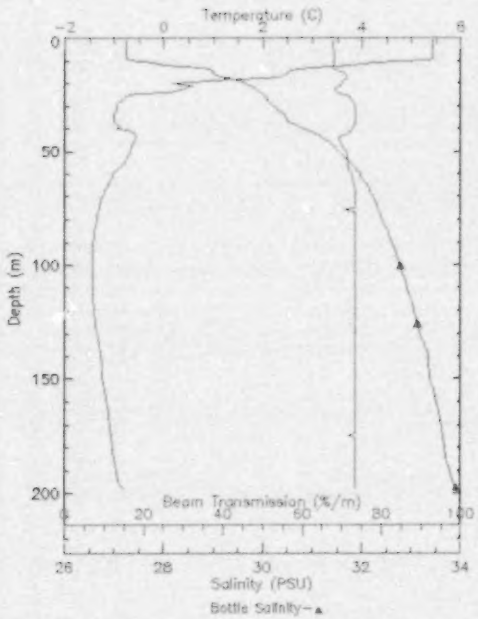


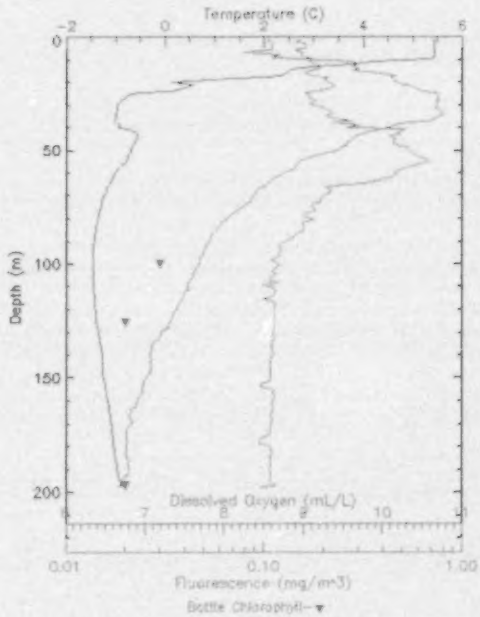


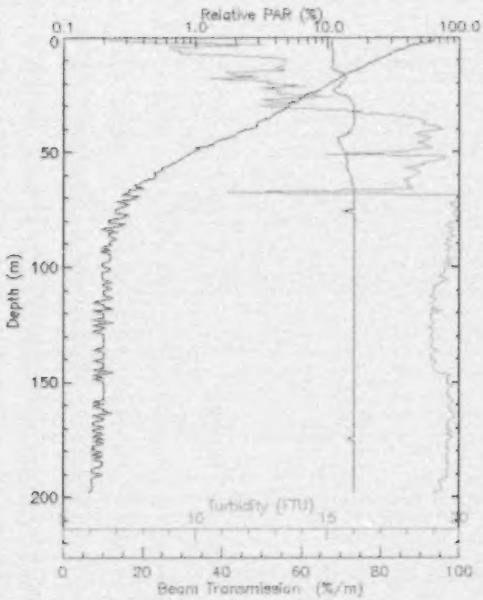




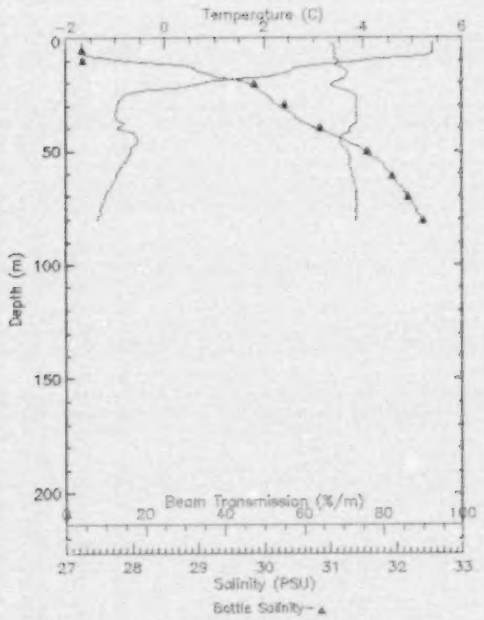
22/08/2013: Cast 48, Station CBH-07 (Upper slope)

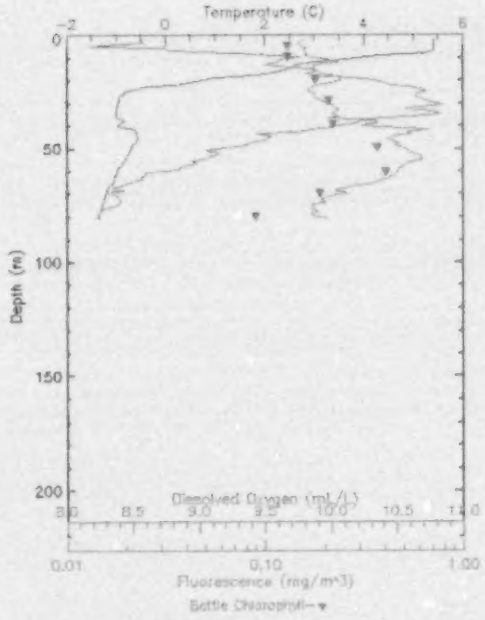


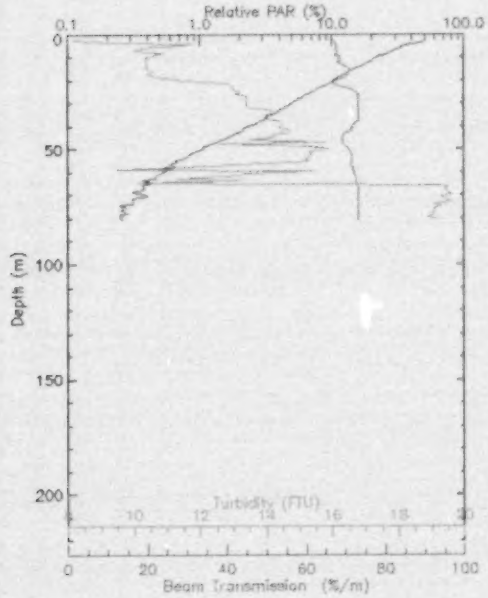




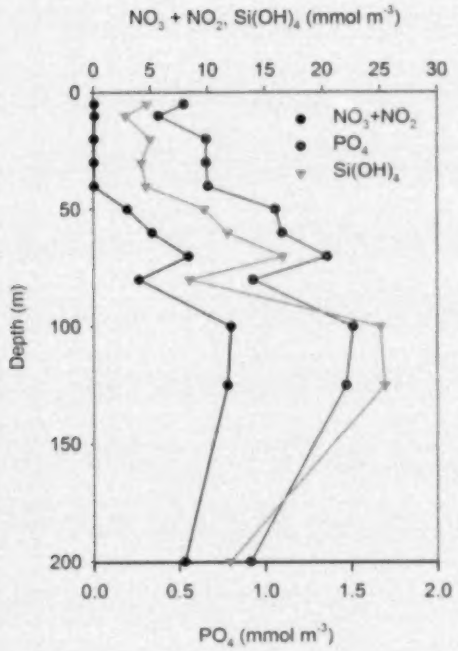
22/08/2013: Cast 49, Station CBH-07 (Upper slope)

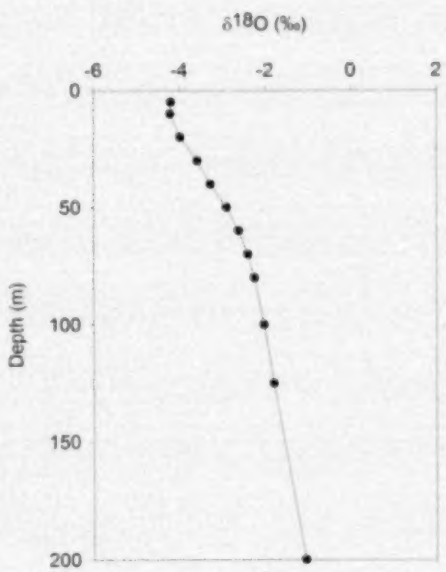


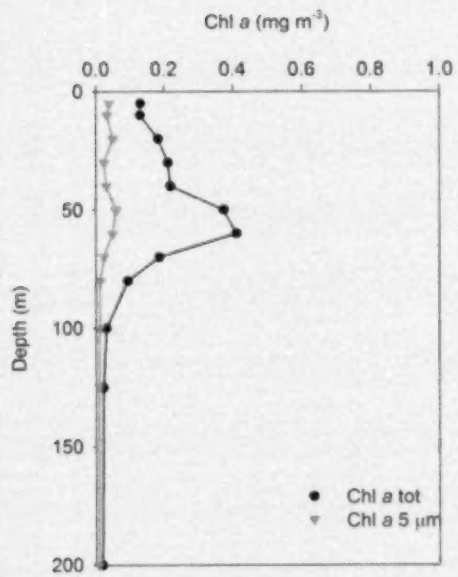


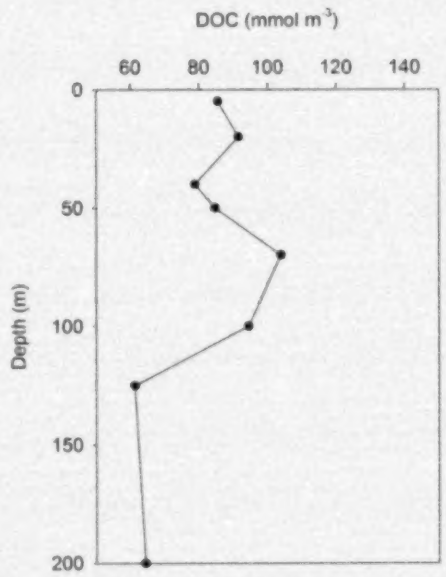


22/08/2013: Cast 48/49, Station CBH-07 (Upper slope)

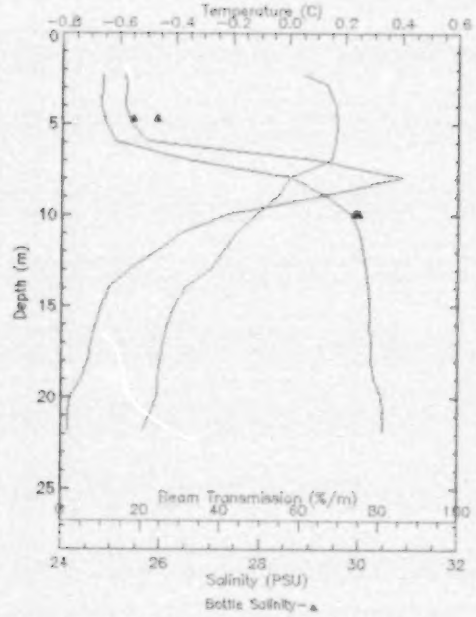


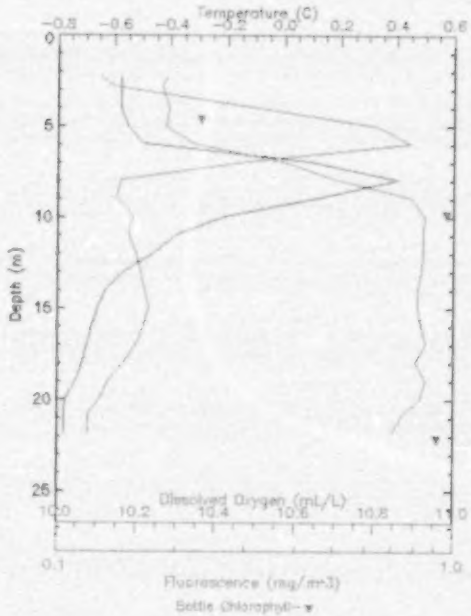


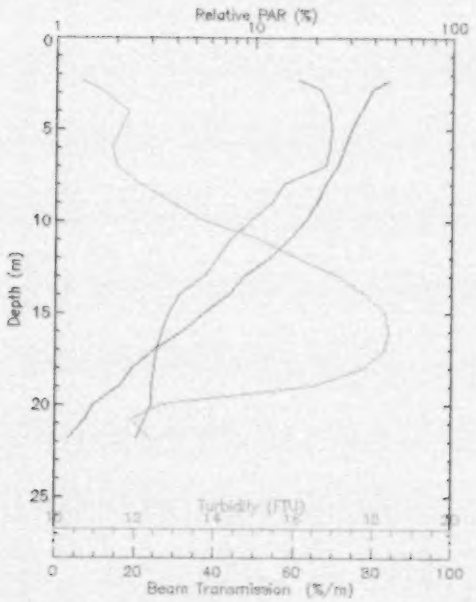




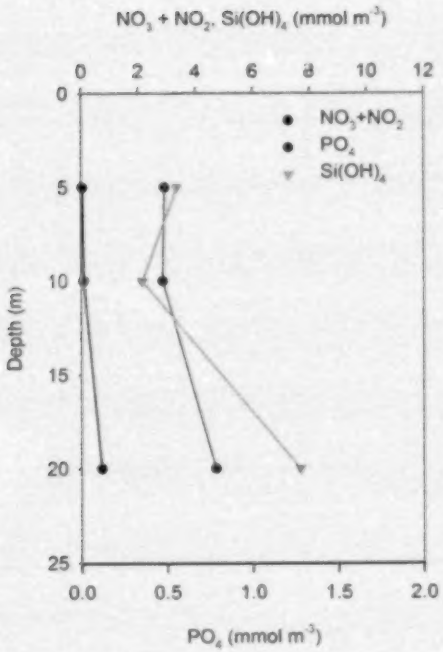
25/08/2013: Cast 50, Station ESC-01 (Near-shore shelf)

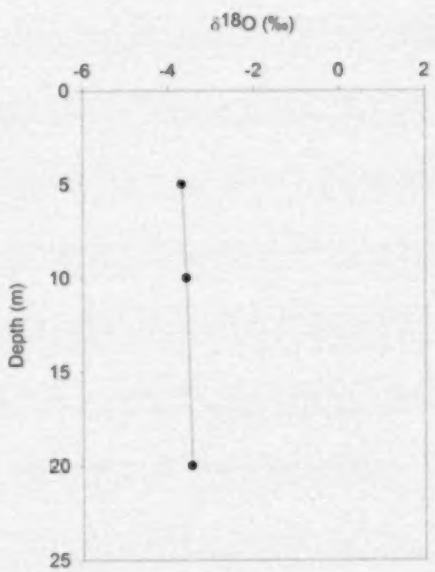


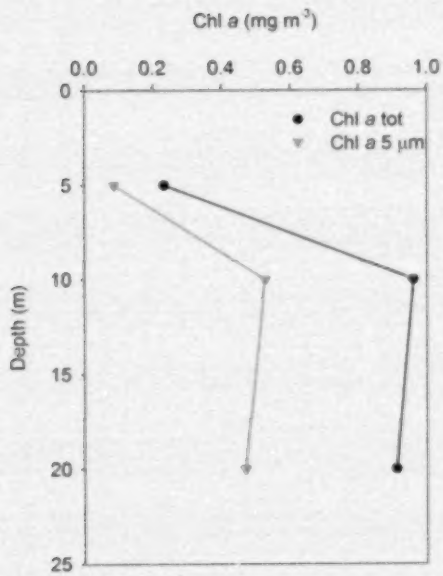


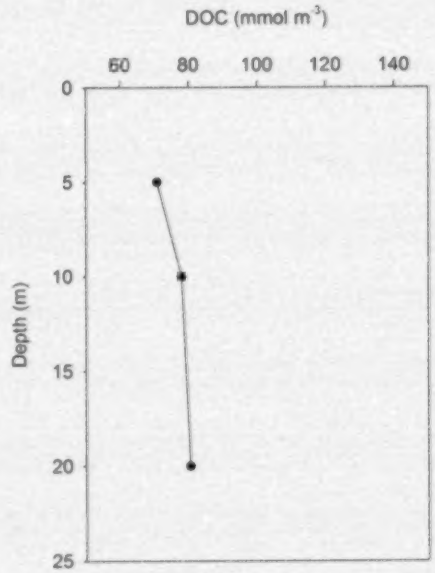


25/08/2013: Cast 50, Station ESC-01 (Near-shore shelf)

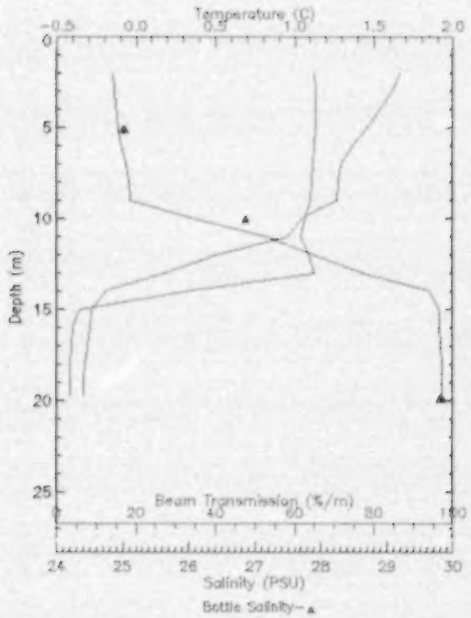


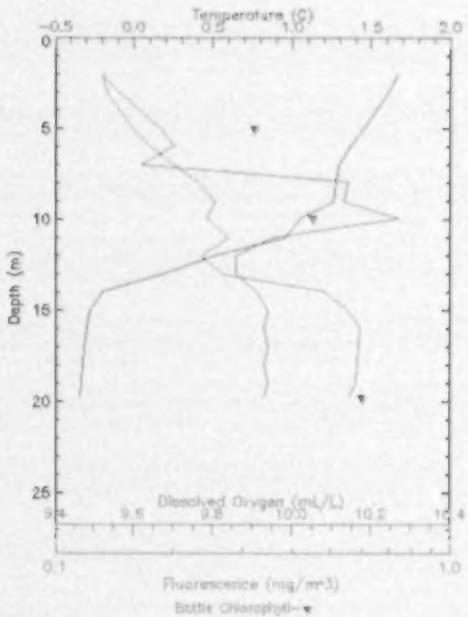


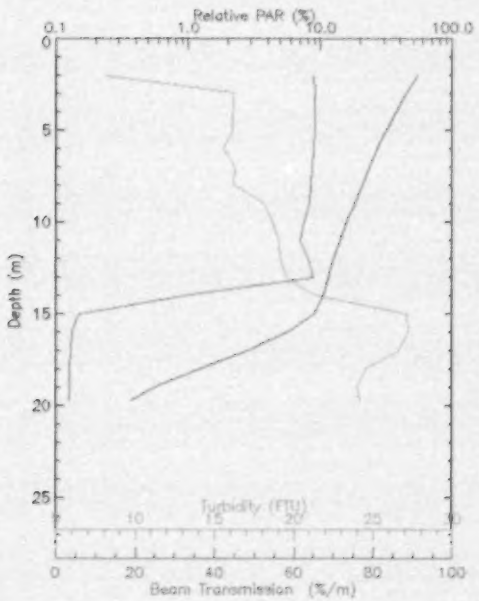




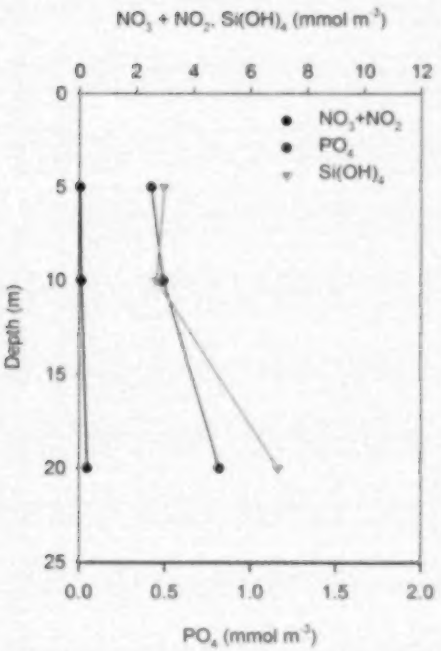
25/08/2013: Cast 51, Station ESC-02 (Near-shore shelf)

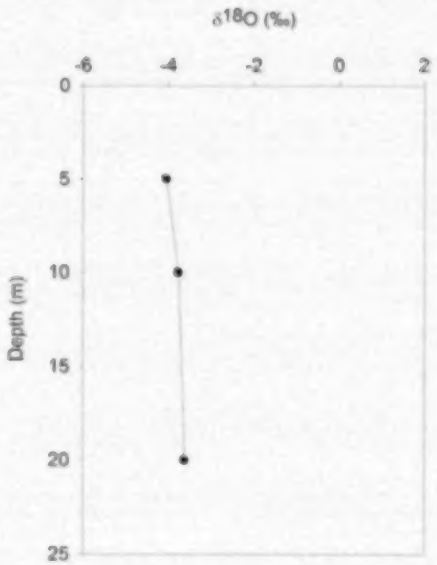

Temperature (C)
−0.5 0.0 0.5 1.0 1.5 2.0
Depth (m)
0 5 10 15 20 25
Beam Transmission (%/m)
0 20 40 60 80 100
24 25 26 27 28 29 30
Salinity (PSU)
Bottle Salinity

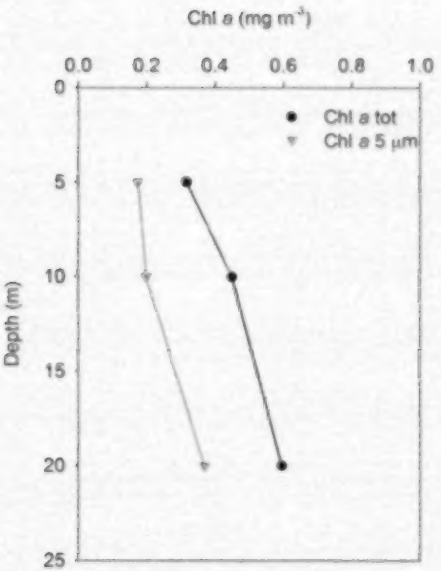


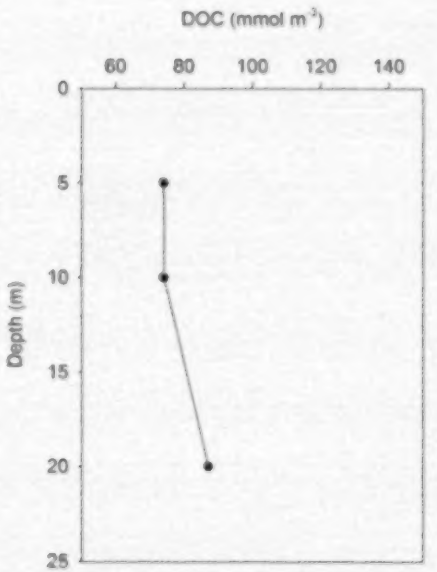


25/08/2013: Cast 51, Station ESC-02 (Near-shore shelf)

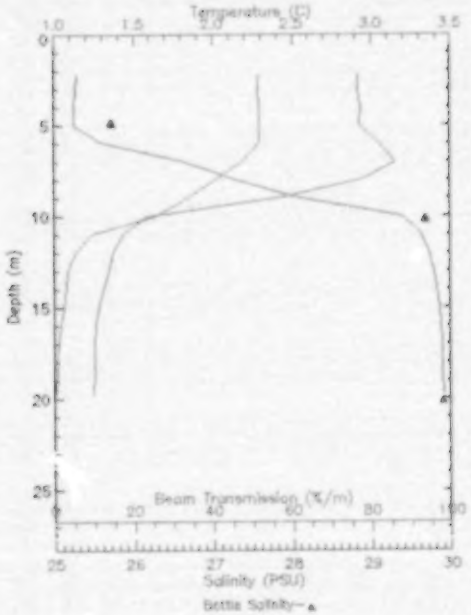


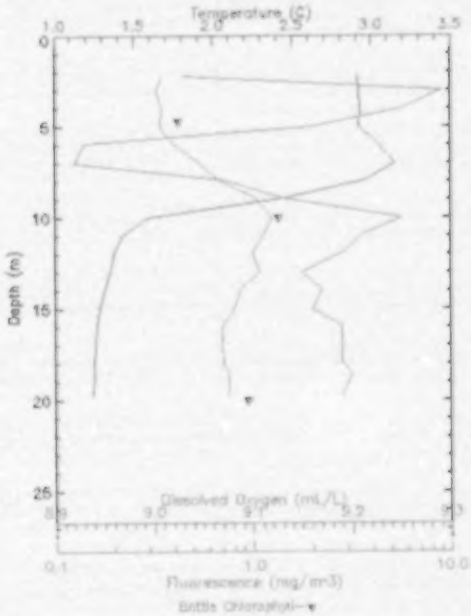


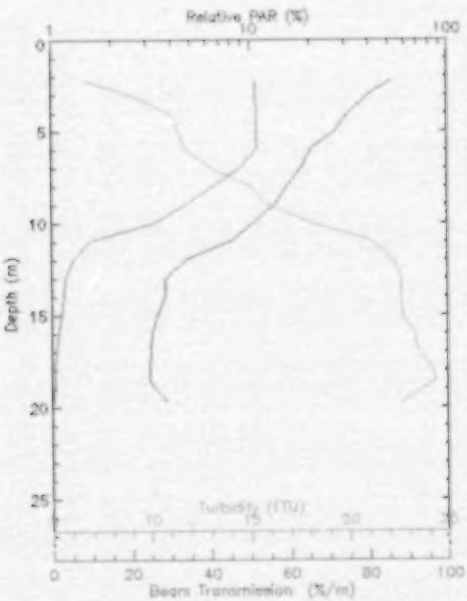




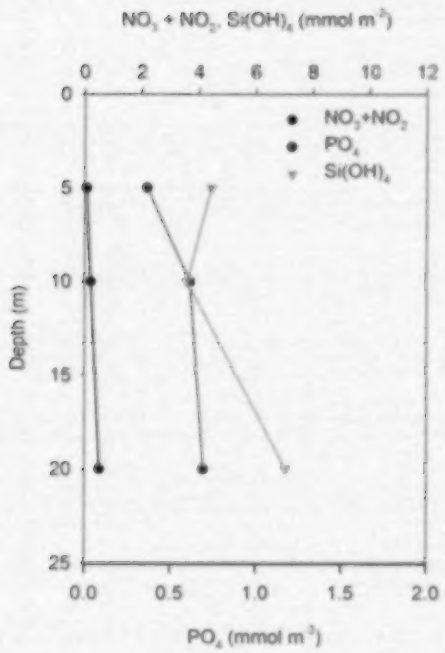
26/08/2013: Cast 52, Station ESC-03 (Near-shore shelf)

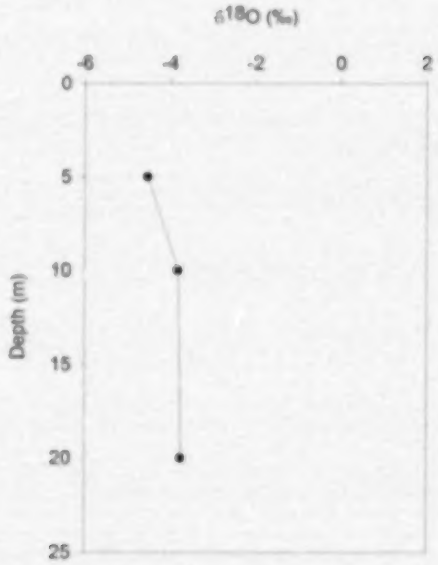


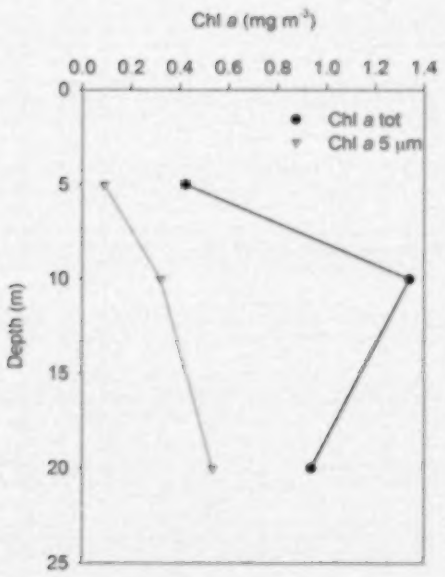


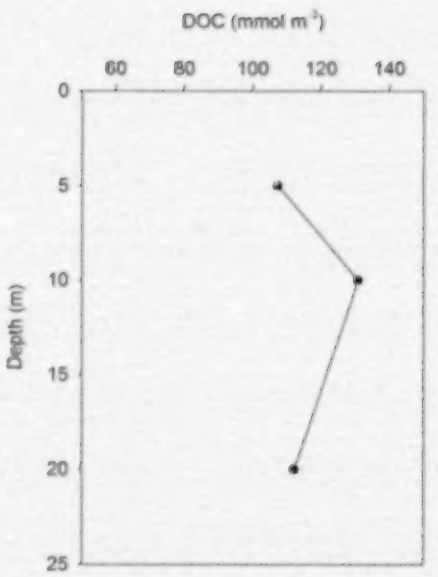


26/08/2013: Cast 52, Station ESC-03 (Near-shore shelf)

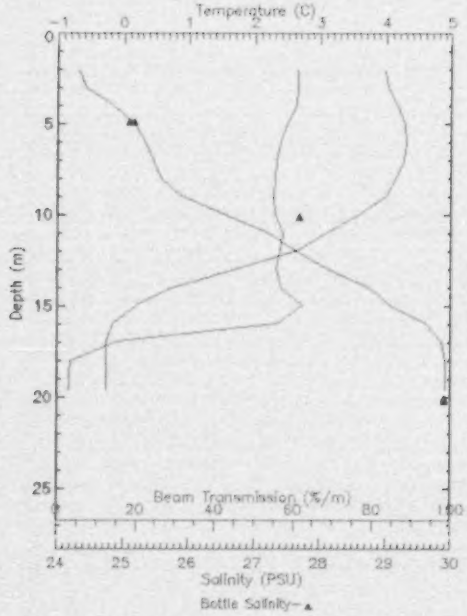


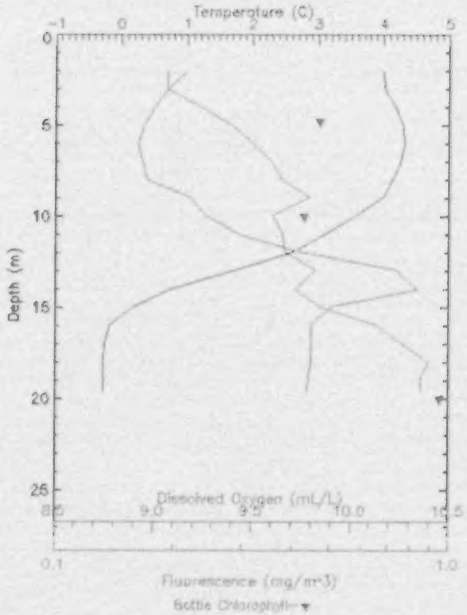


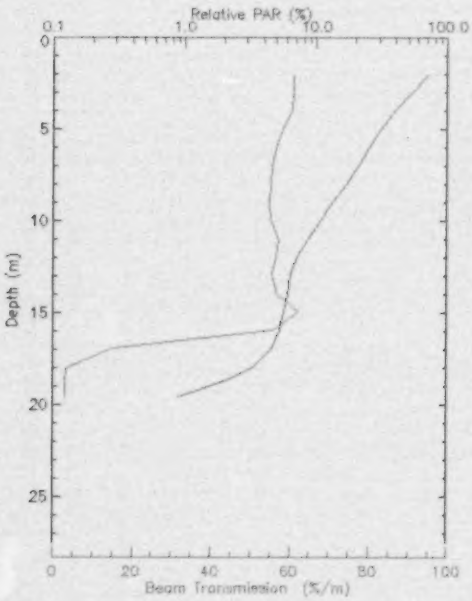




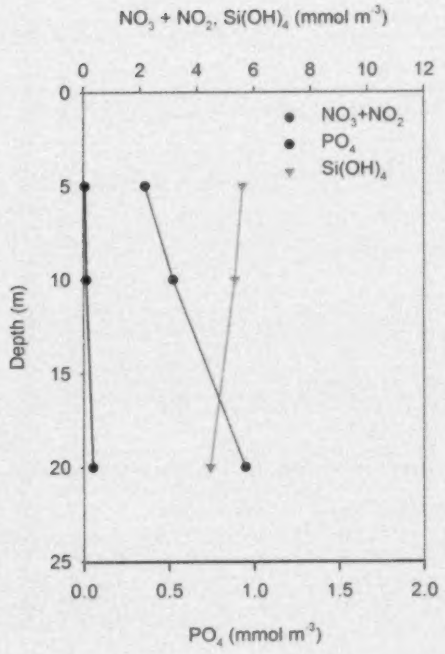
26/08/2013: Cast 53, Station ESC-04 (Near-shore shelf)

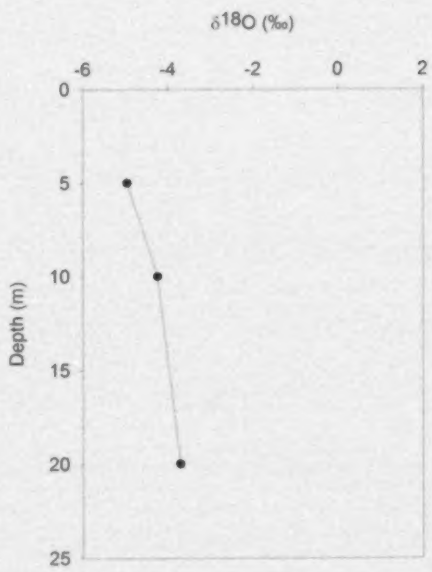


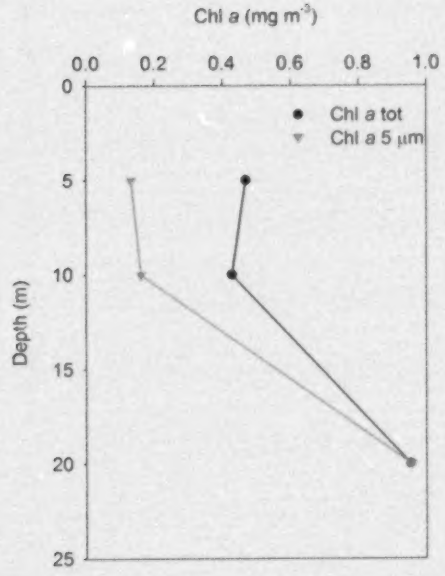


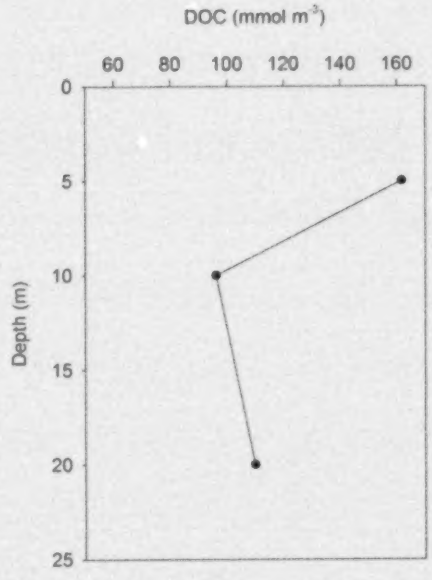


26/08/2013: Cast 53, Station ESC-04 (Near-shore shelf)

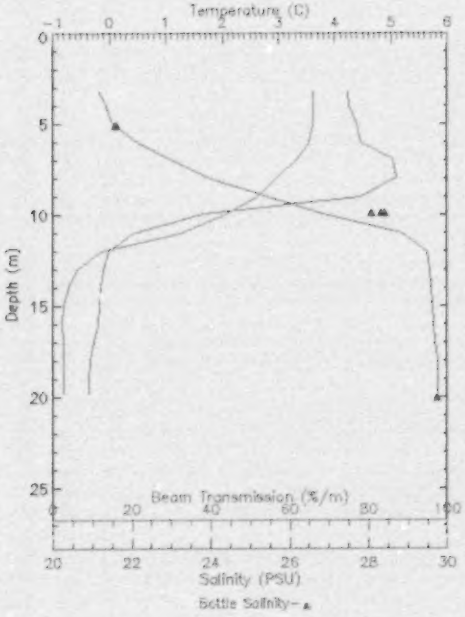


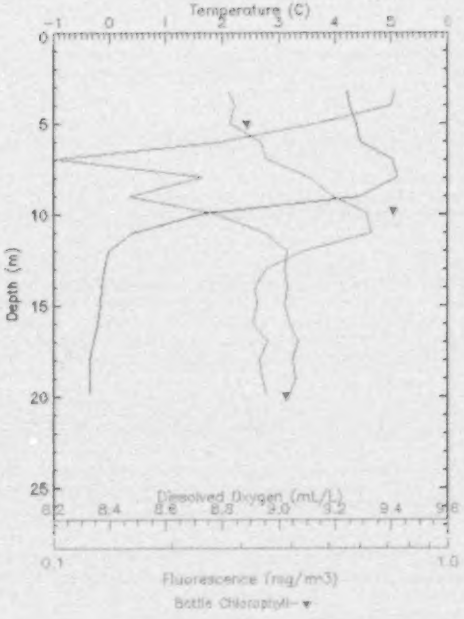


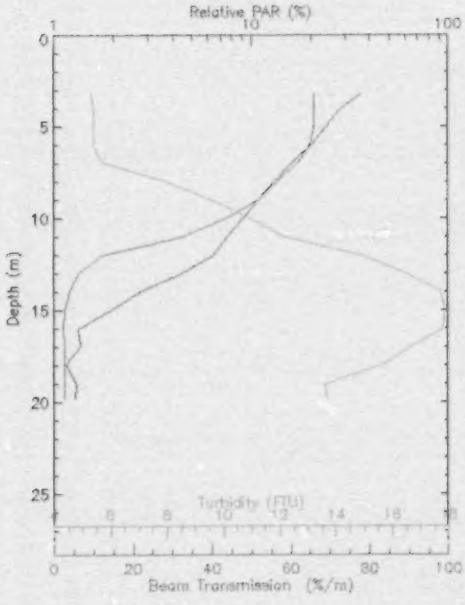




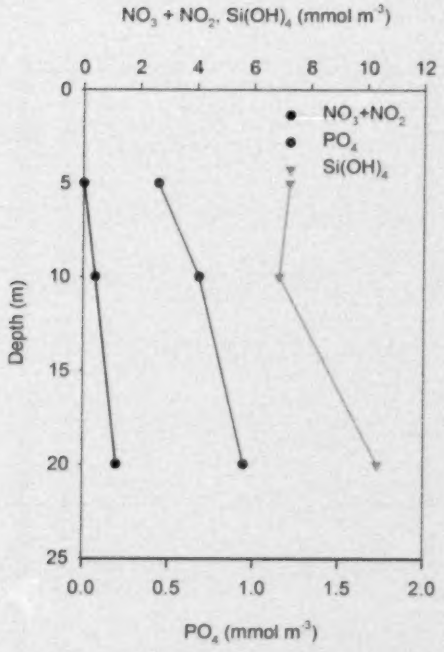
27/08/2013: Cast 54, Station ESC-05 (Near-shore shelf)

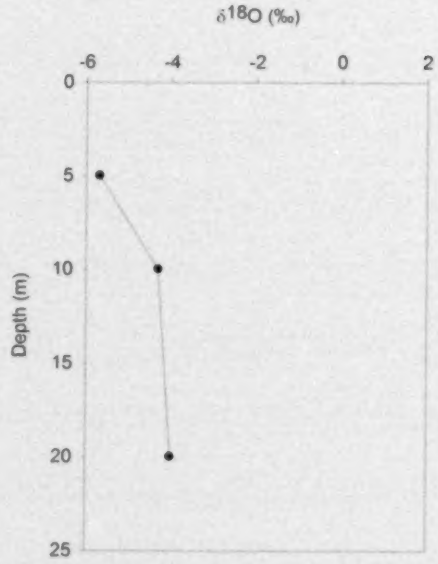


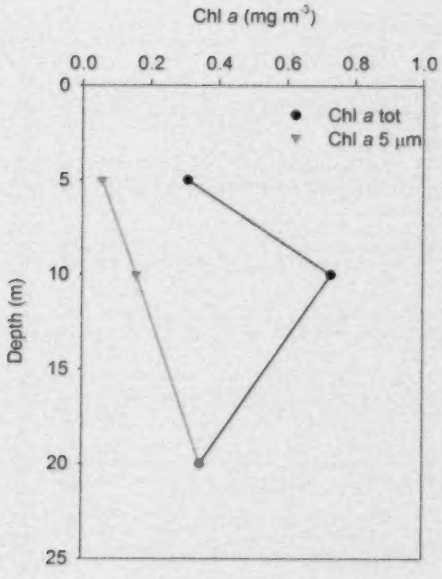


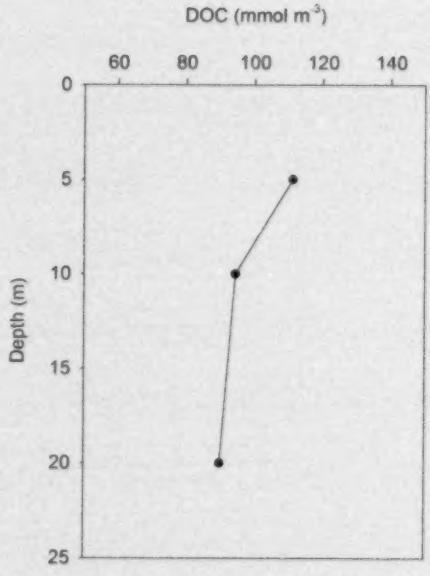


27/08/2013: Cast 54, Station ESC-05 (Near-shore shelf)



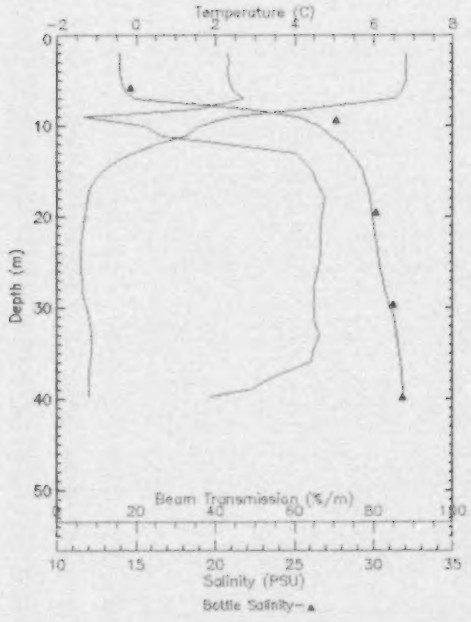


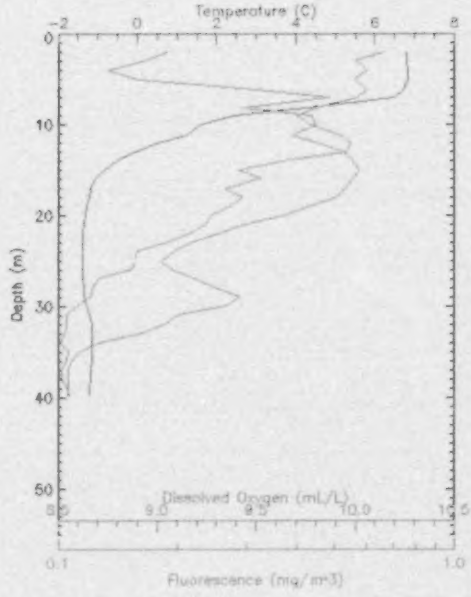


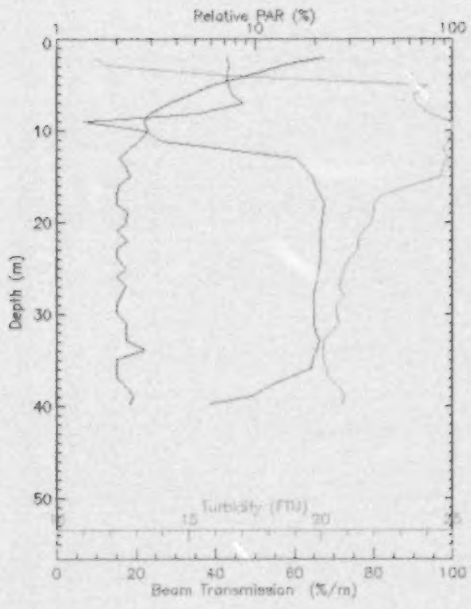


Appendix 3. CTD/Rosette station plots from leg 2 of the BREA Marine Fishes project, August-September 2013. Plots are identified by station name and sampling date, expedition cast number and fish habitat grouping. CTD plots for each cast (temperature, salinity, transmissivity, fluorescence, dissolved oxygen (DO), photosynthetically active radiation (PAR), and turbidity) are presented first, followed by the rosette plots (inorganic nutrients ($NO_3 + NO_2$, PO_4, $Si(OH)_4$) and $\delta^{18}O$) for each station. Transect and cast details are provided in Figure 1 and Appendix 1.

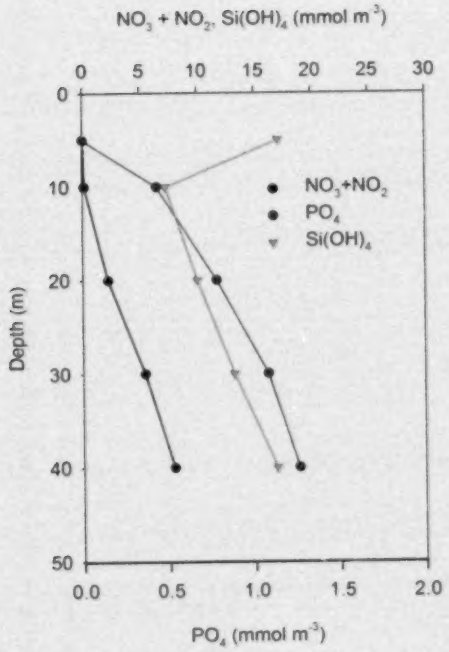
29/08/2013: Cast 55, Station GRY-01 (Near-shore shelf)

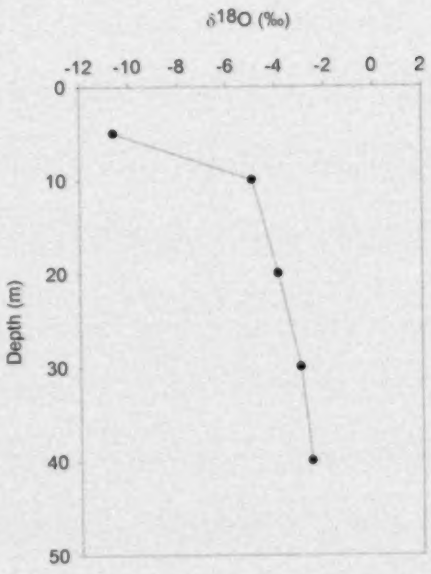




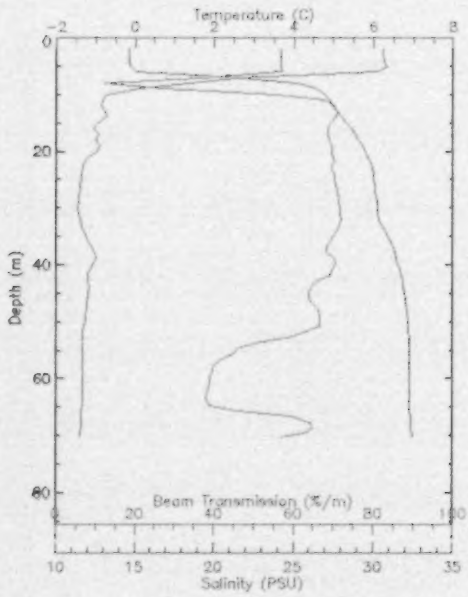


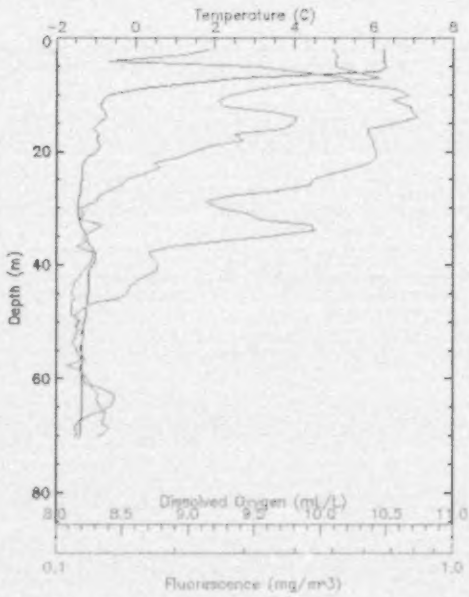
29/08/2013: Cast 55, Station GRY-01 (Near-shore shelf)

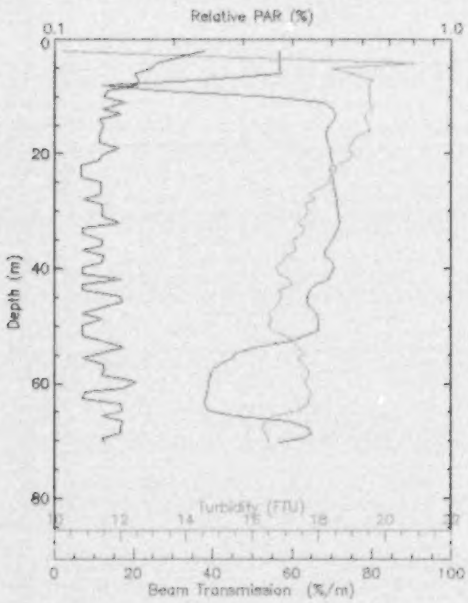




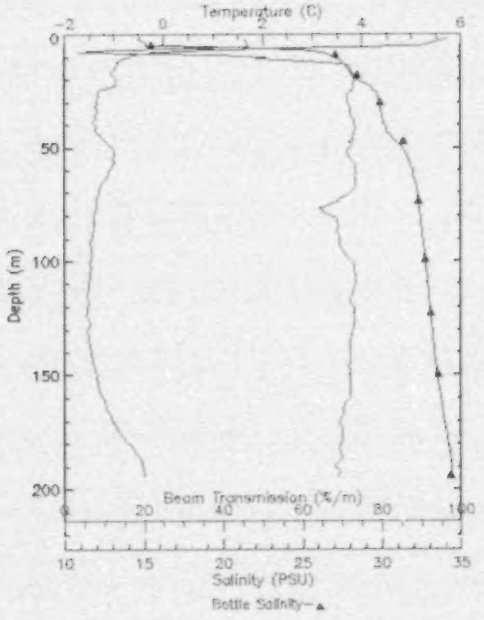
29/08/2013: Cast 56, Station GRY-02 (Off-shore shelf)

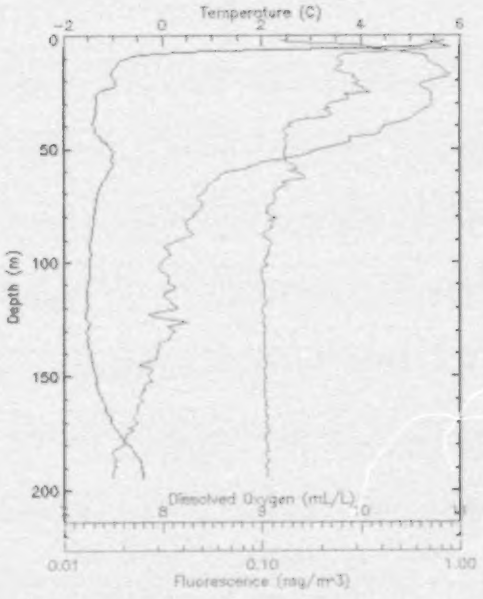


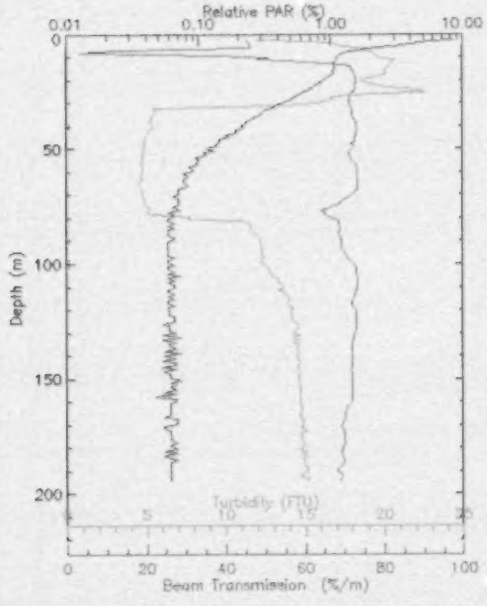




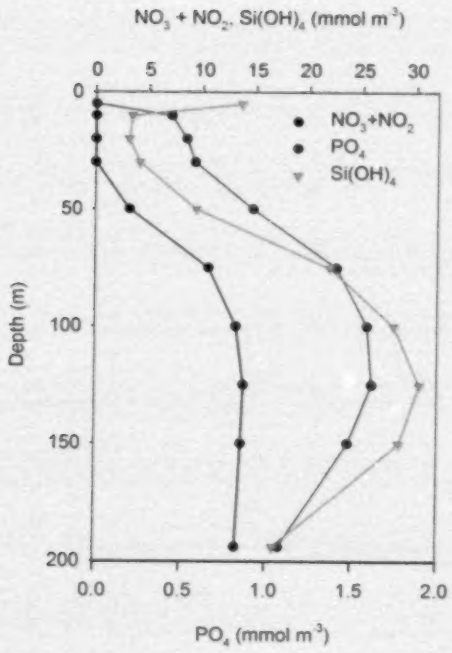
29/08/2013: Cast 57, Station GRY-03 (Off-shore shelf)

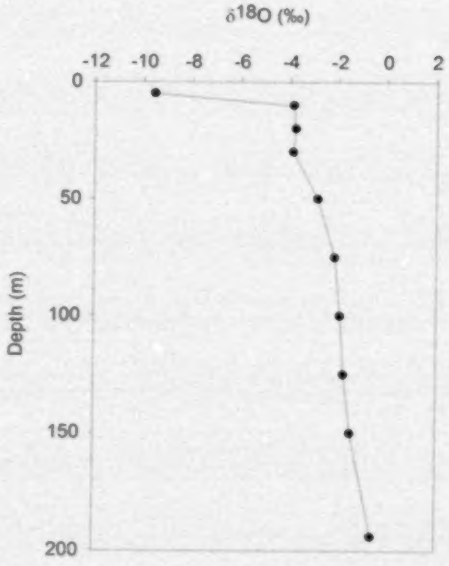




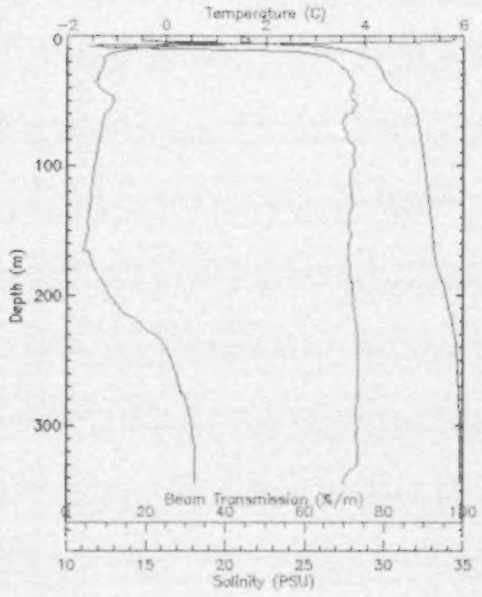


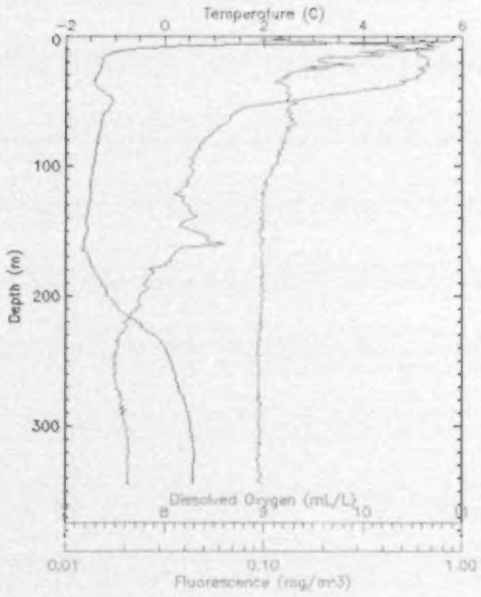
29/08/2013: Cast 57, Station GRY-03 (Off-shore shelf)

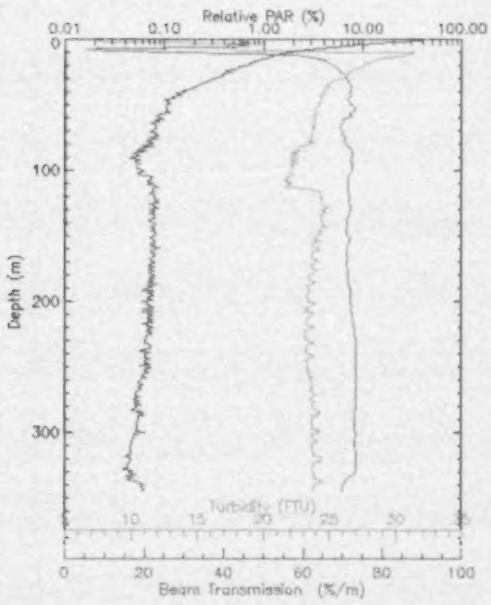




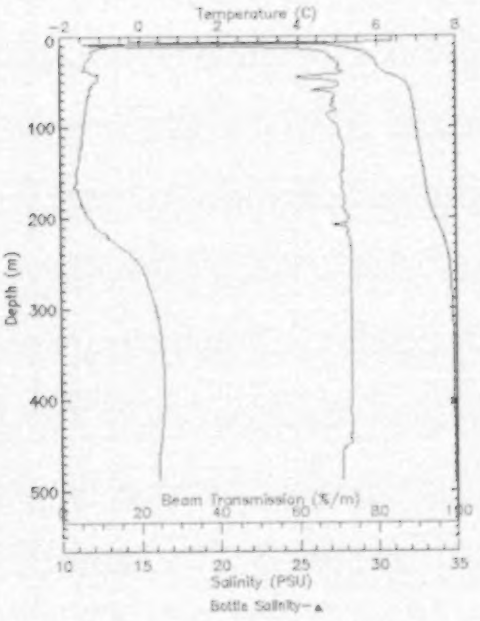
29/08/2013: Cast 58, Station GRY-04 (Upper slope)

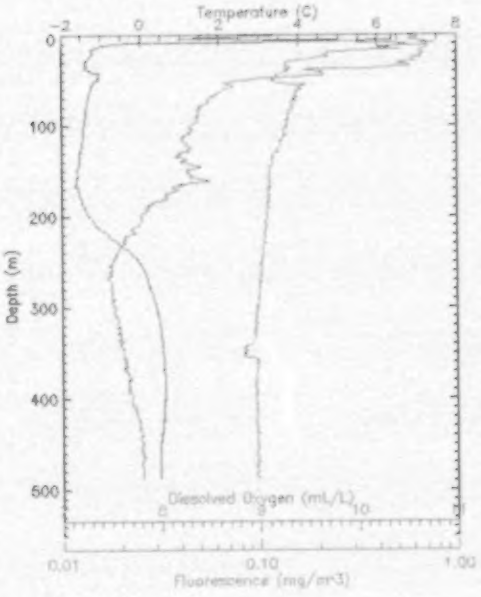


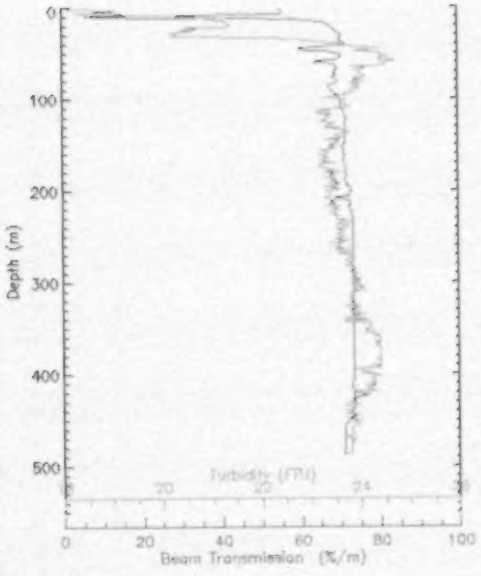




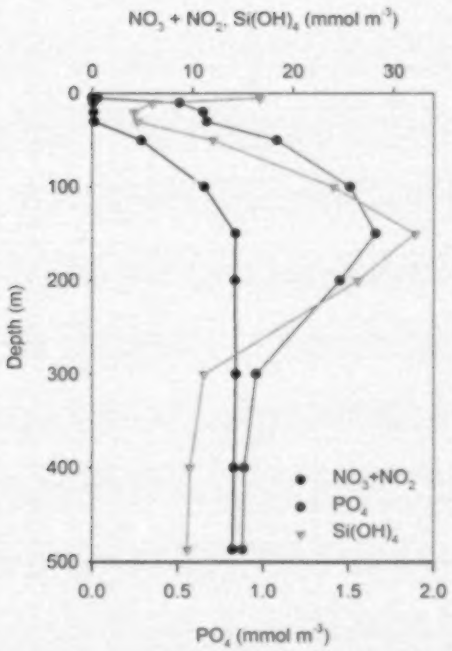
30/08/2013: Cast 59, Station GRY-05 (Upper slope)

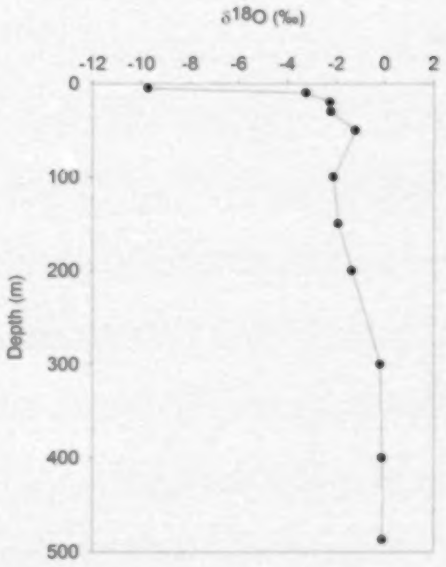




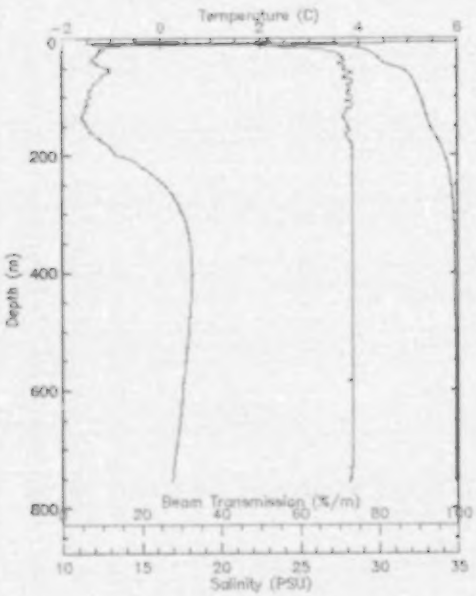


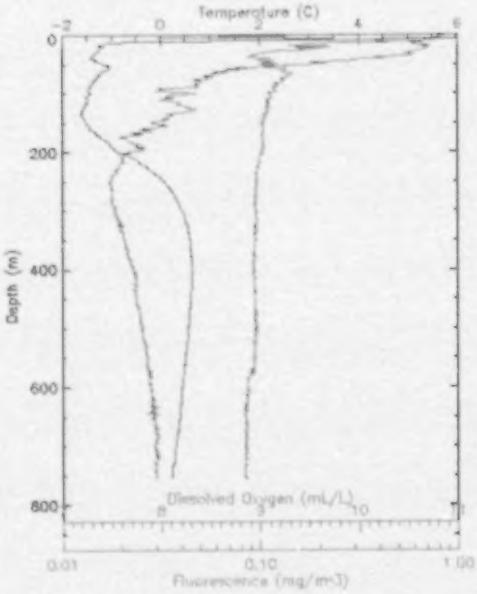
30/08/2013: Cast 59, Station GRY-05 (Upper slope)

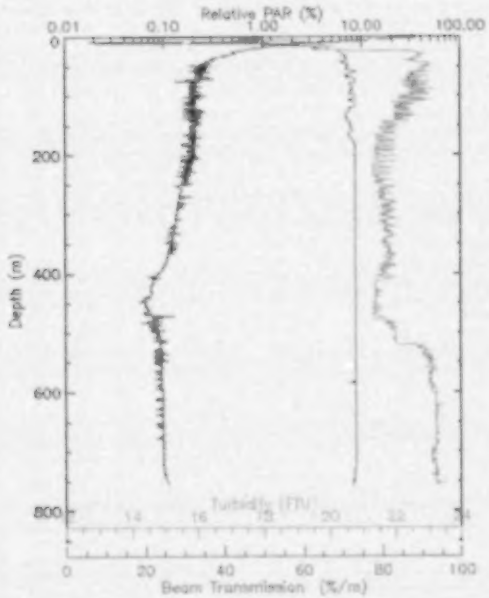




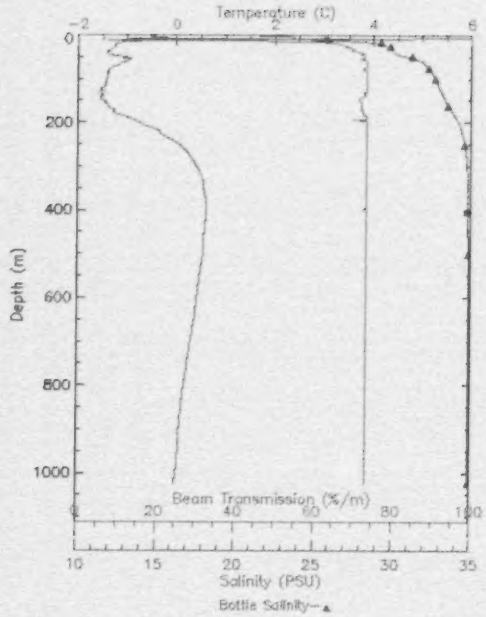
30/08/2013: Cast 60, Station GRY-06 (Lower slope)

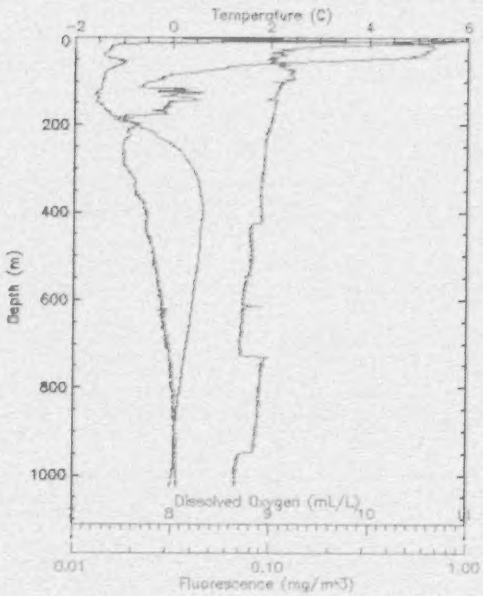


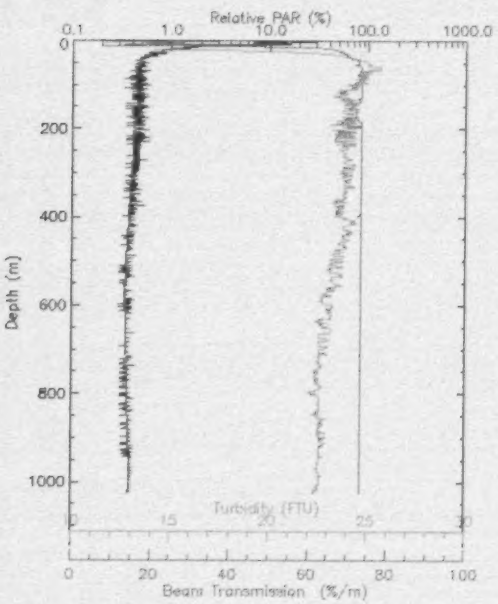




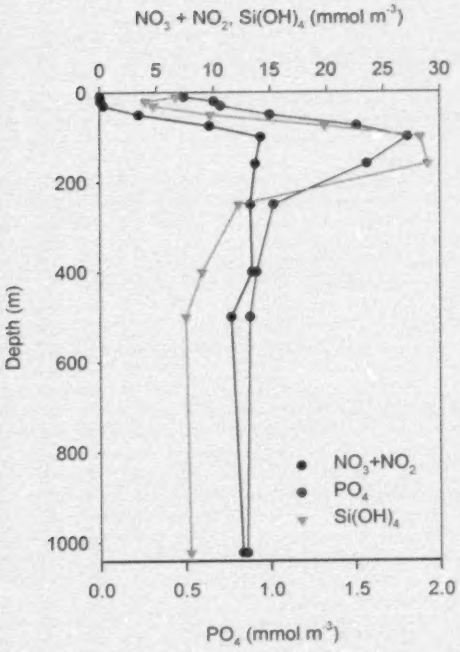
31/08/2013: Cast 61, Station GRY-07 (Lower slope)

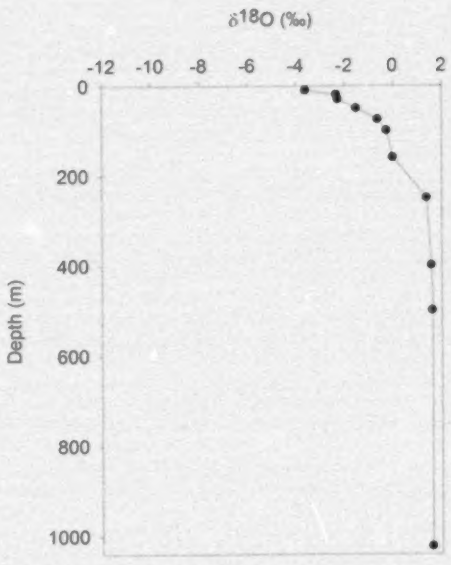




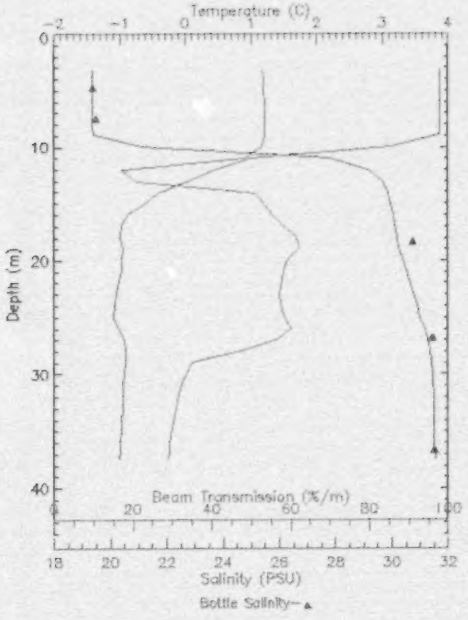


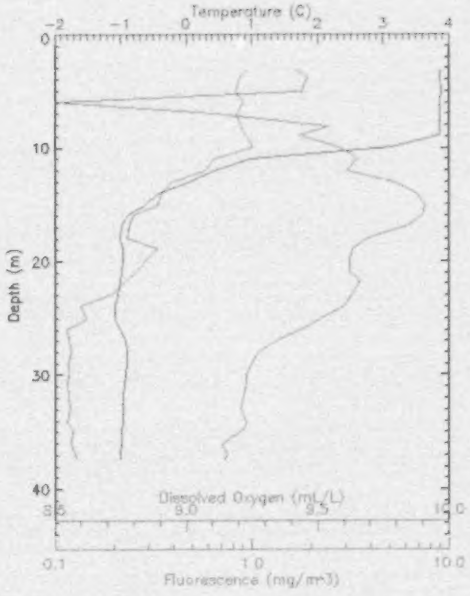
31/08/2013: Cast 61, Station GRY-07 (Lower slope)

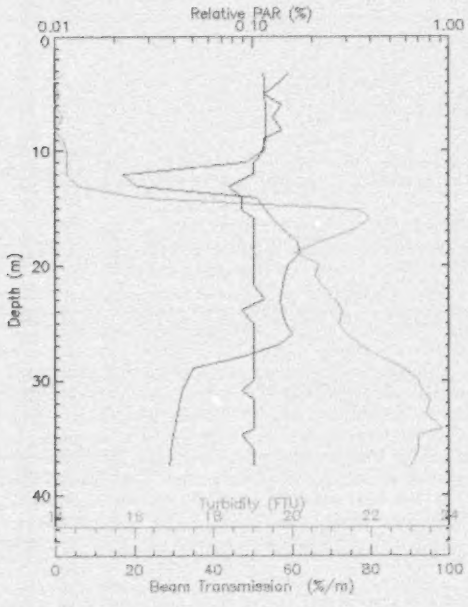




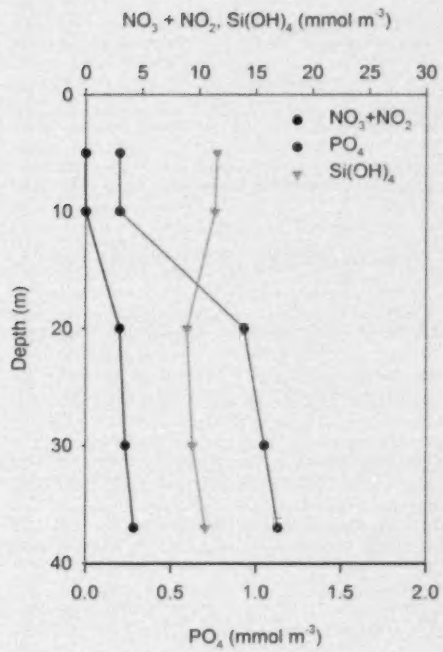
02/09/2013: Cast 62, Station TBS-01 (Near-shore shelf)

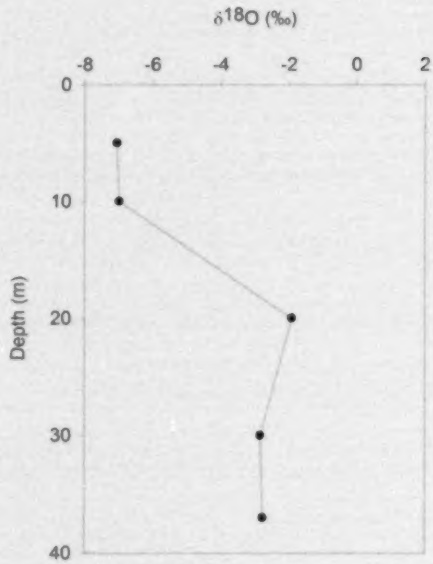




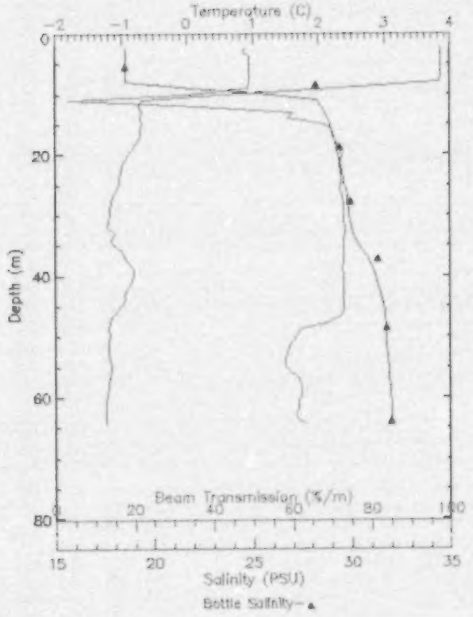


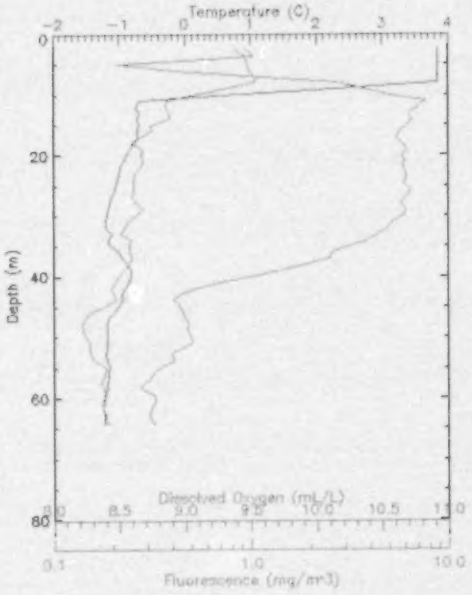
02/09/2013: Cast 62, Station TBS-01 (Near-shore shelf)

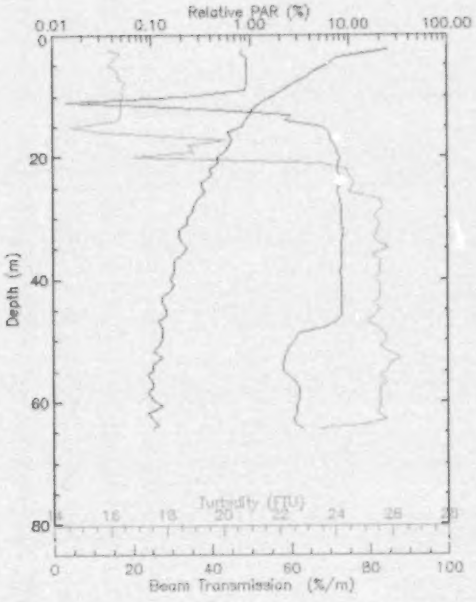




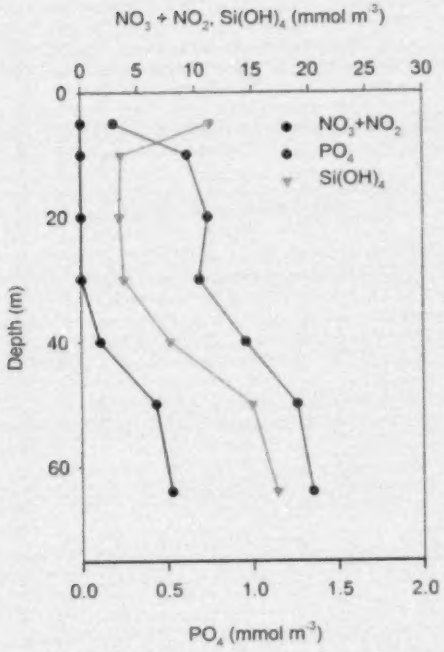
02/09/2013: Cast 63, Station TBS-02 (Near-shore shelf)

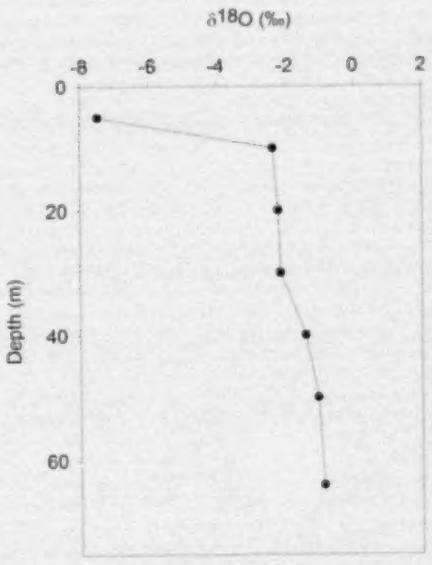




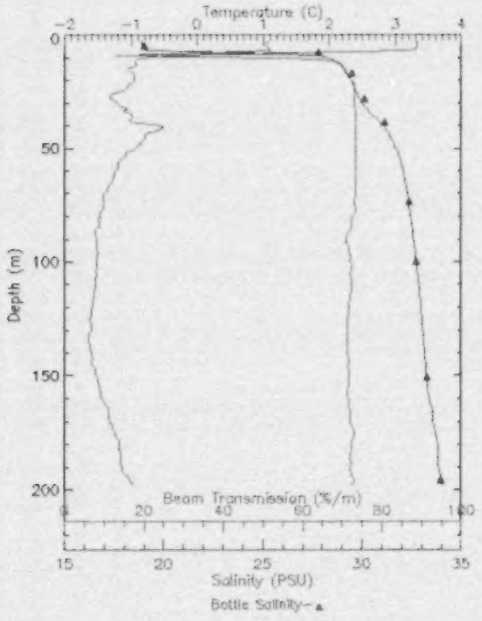


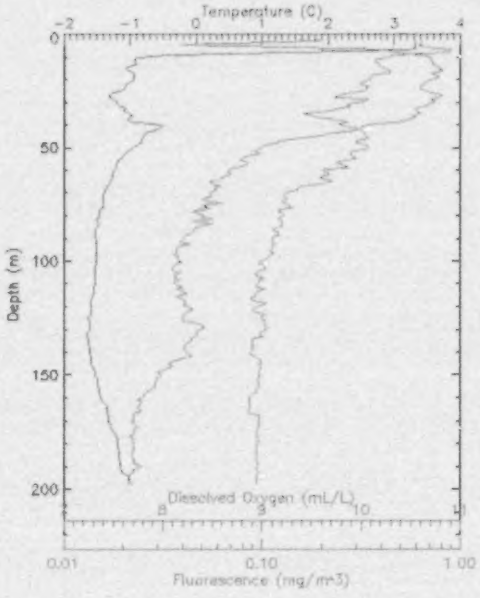
02/09/2013: Cast 63, Station TBS-02 (Near-shore shelf)

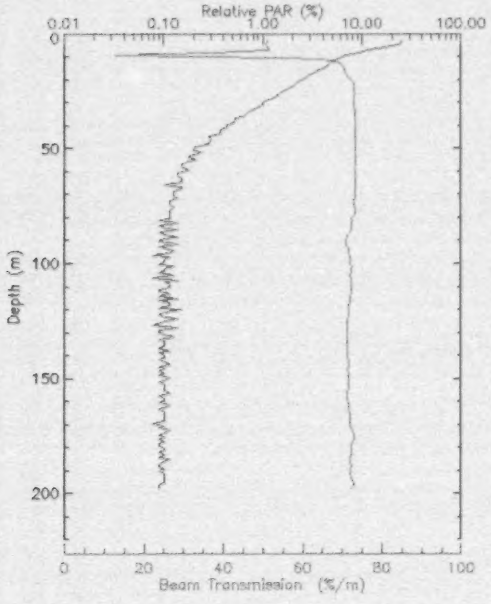




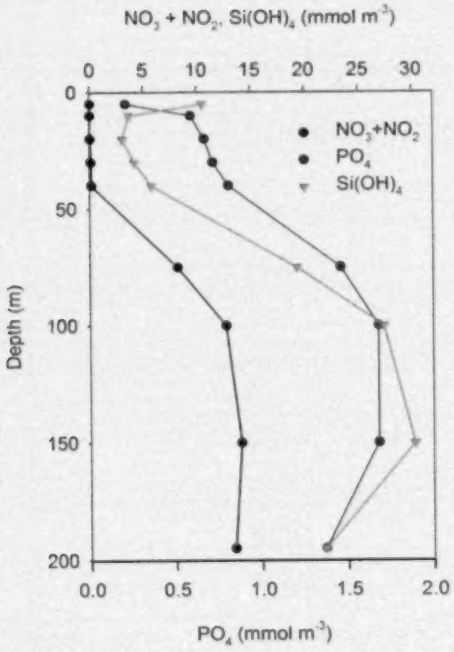
02/09/2013: Cast 64, Station TBS-03 (Upper slope)

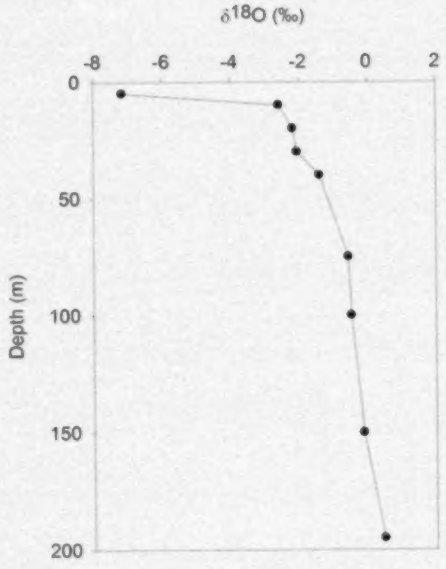




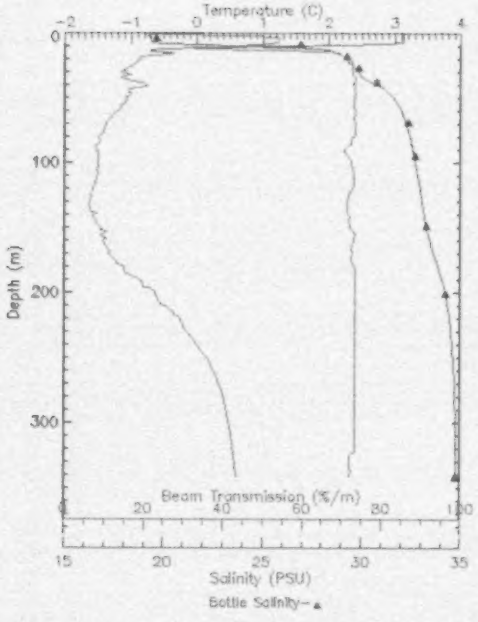


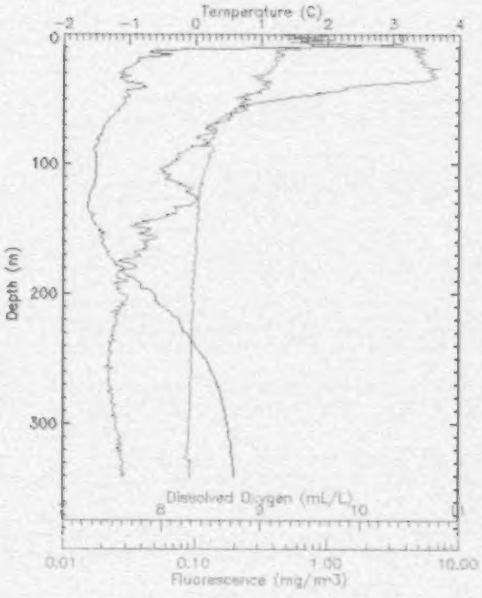
02/09/2013: Cast 64, Station TBS-03 (Upper slope)

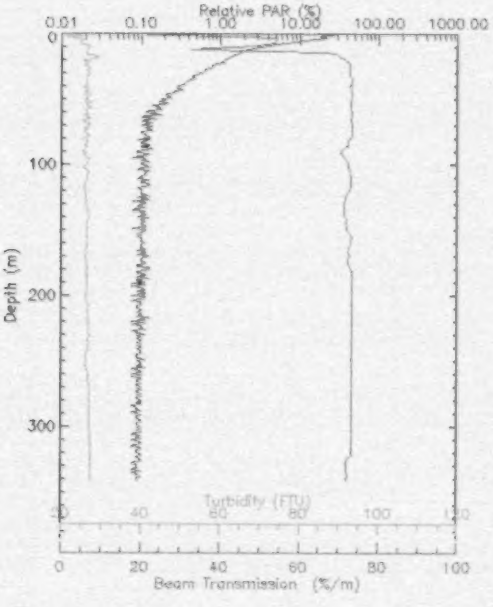




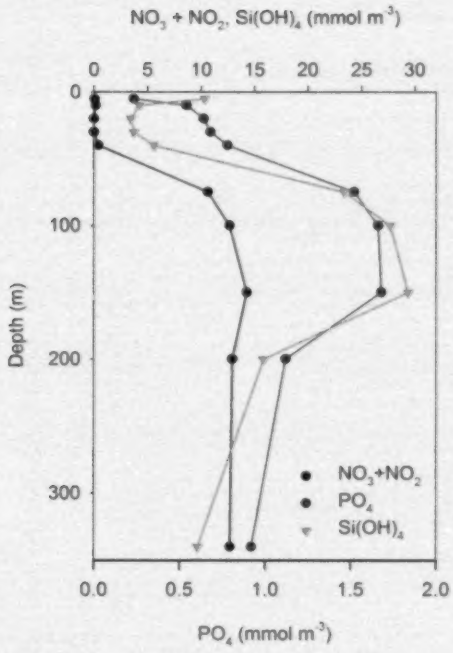
02/09/2013: Cast 65, Station TBS-04 (Upper slope)

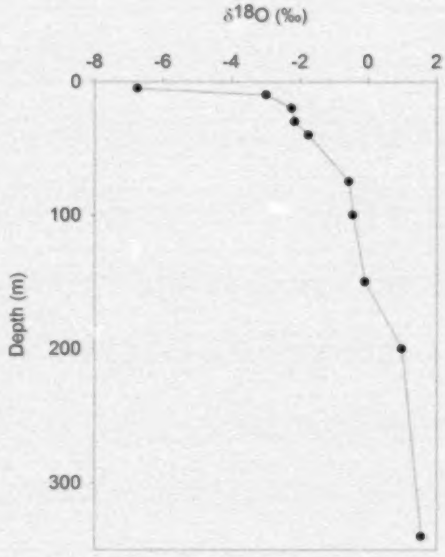




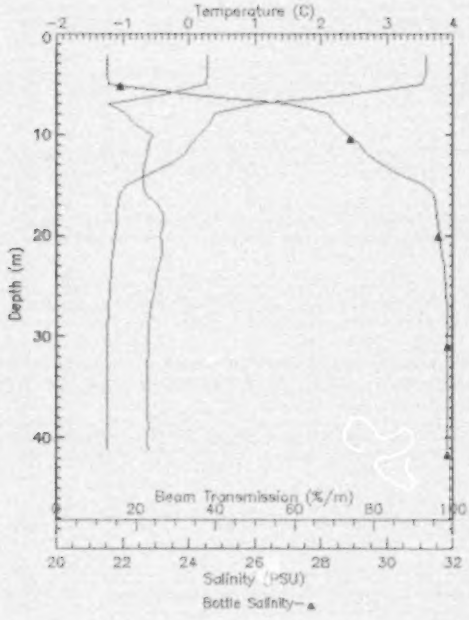


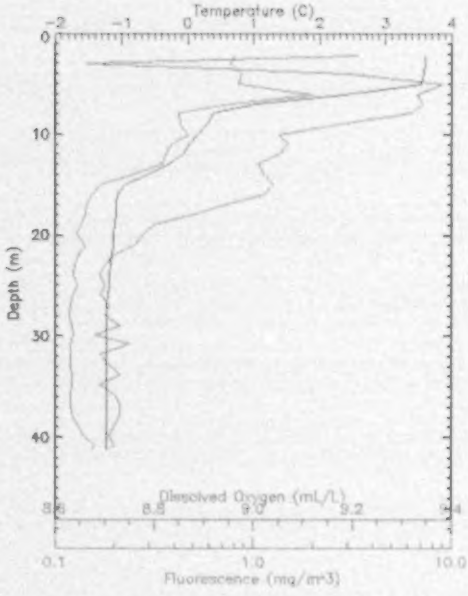
02/09/2013: Cast 65, Station TBS-04 (Upper slope)

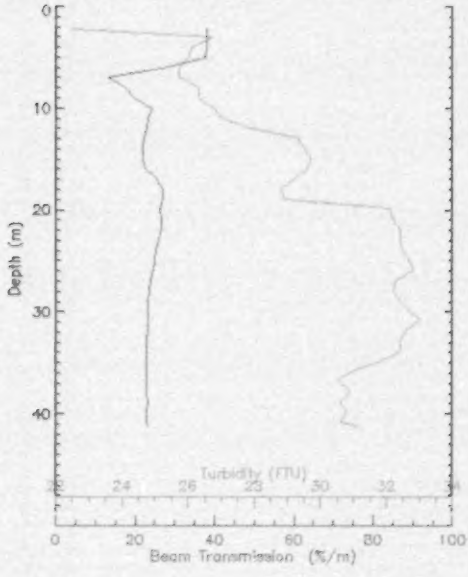




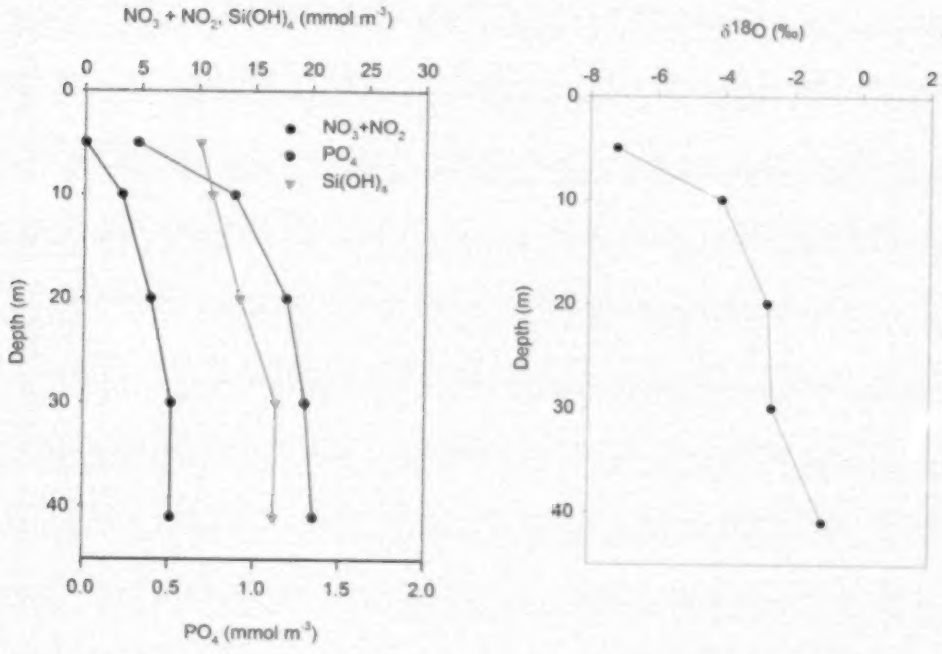
05/09/2013: Cast 68, Station A1-01 (Near-shore shelf)



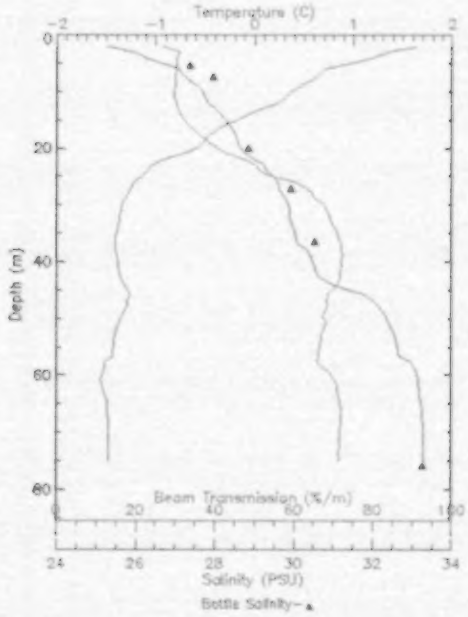


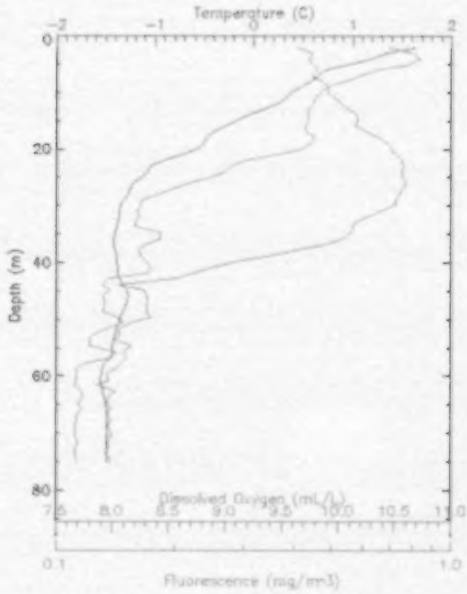


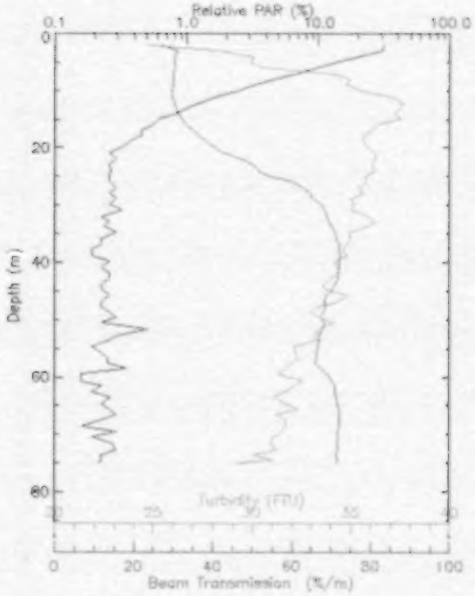
05/09/2013: Cast 68, Station A1-01 (Near-shore shelf)



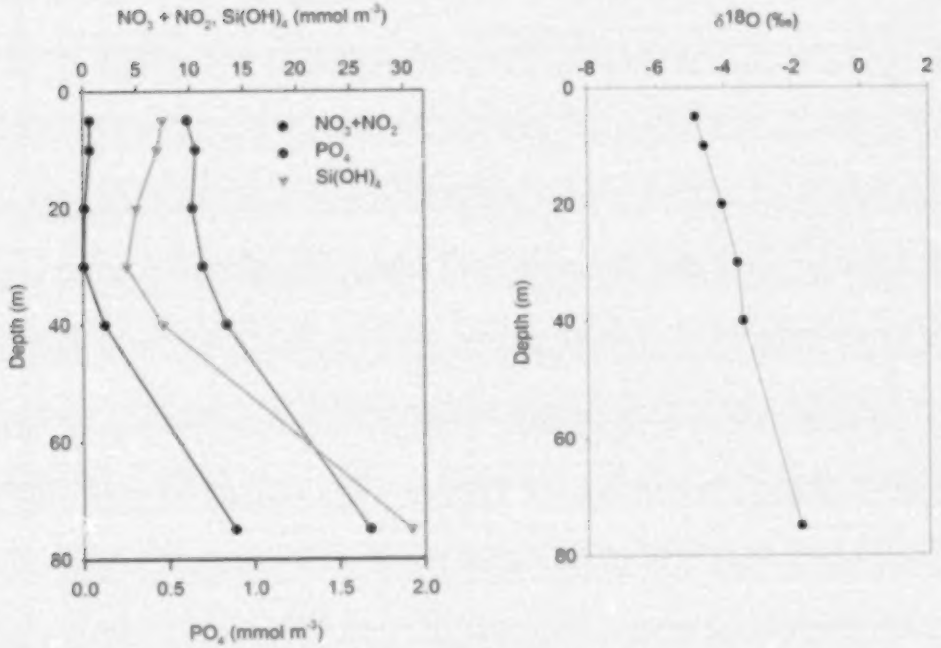
05/09/2013: Cast 69, Station A1-02 (Off-shore shelf)



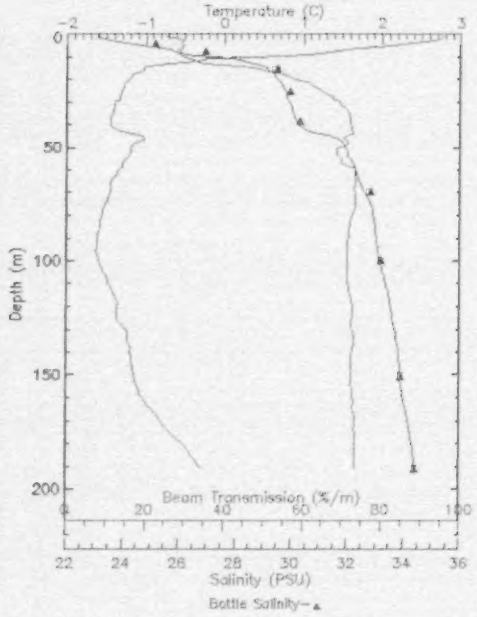


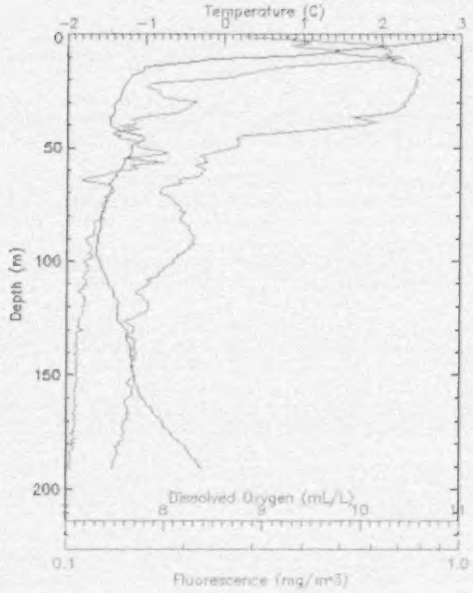


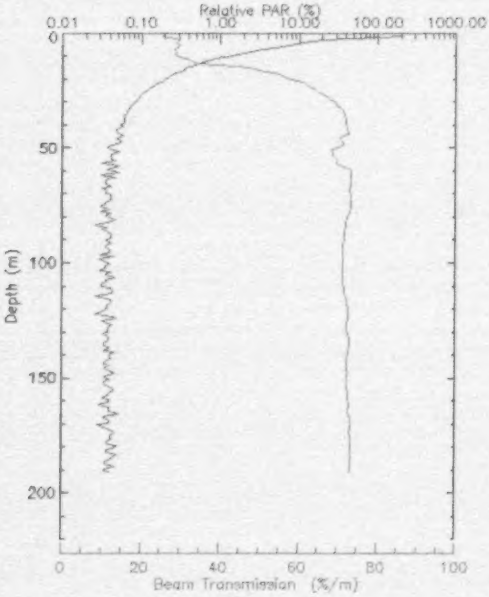
05/09/2013: Cast 69, Station A1-02 (Off-shore shelf)



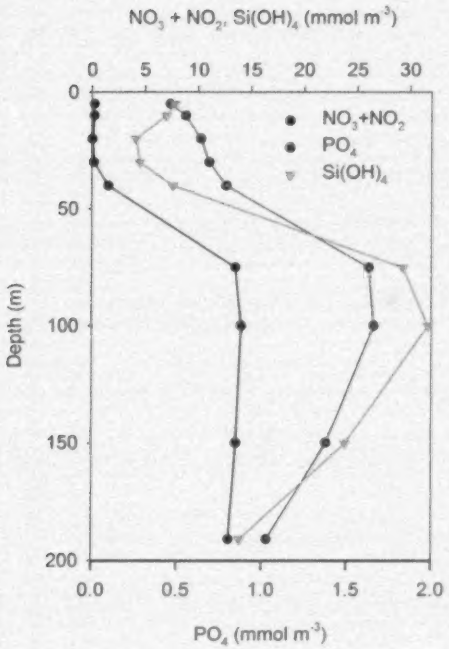
05/09/2013: Cast 70, Station A1-03 (Off-shore shelf)

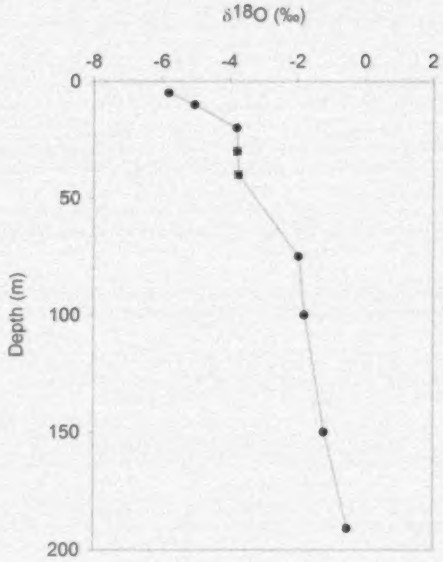




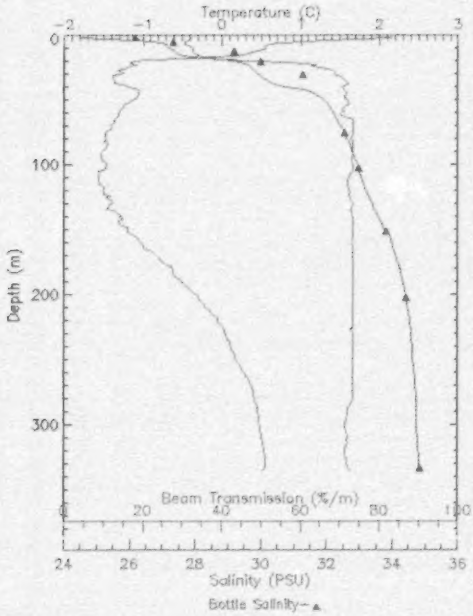


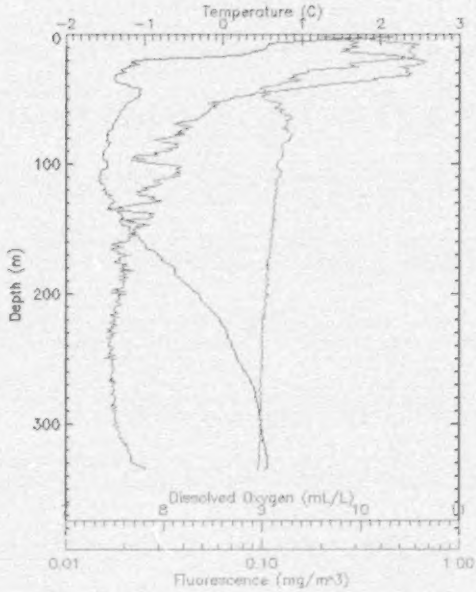
05/09/2013: Cast 70, Station A1-03 (Off-shore shelf)

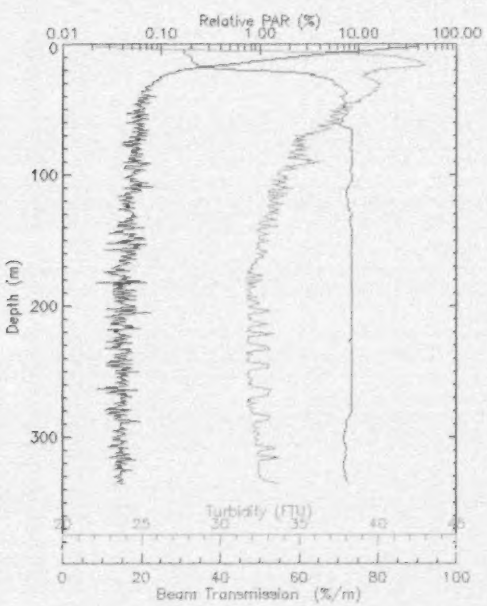




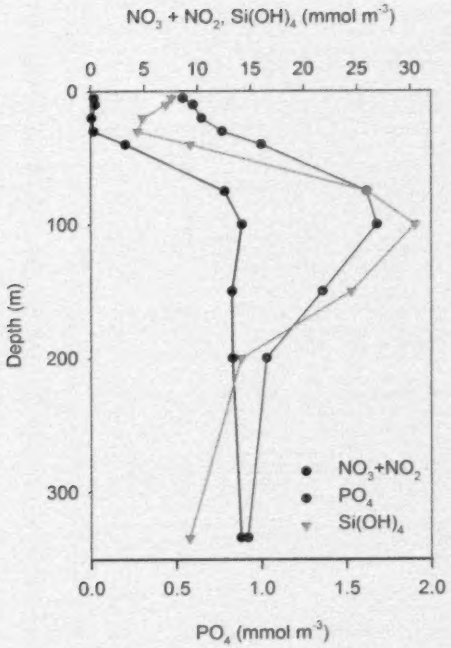
05/09/2013: Cast 71, Station A1-04 (Upper slope)

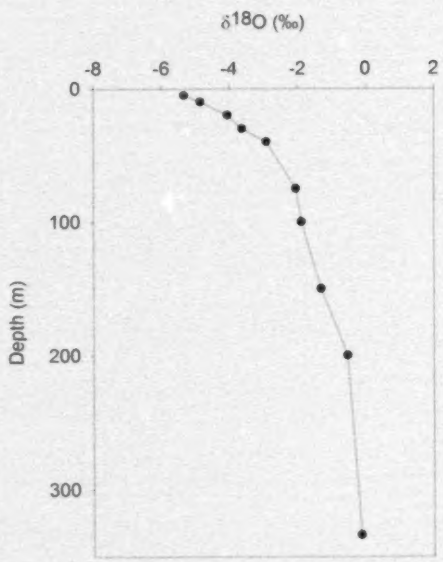




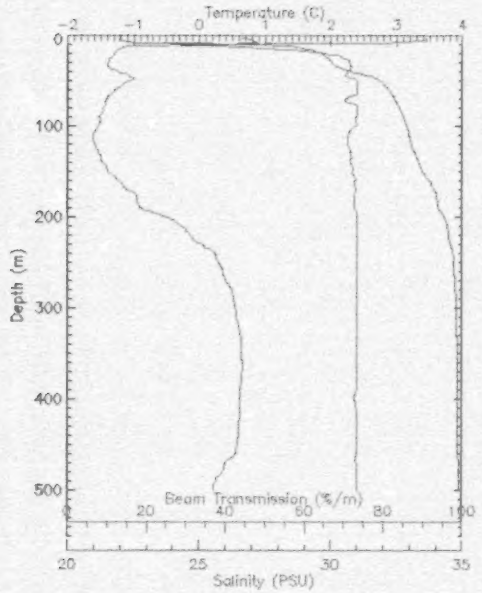


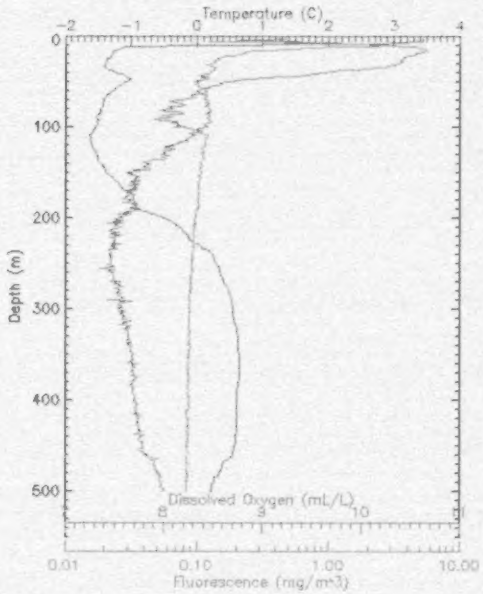
05/09/2013: Cast 71, Station A1-04 (Upper slope)

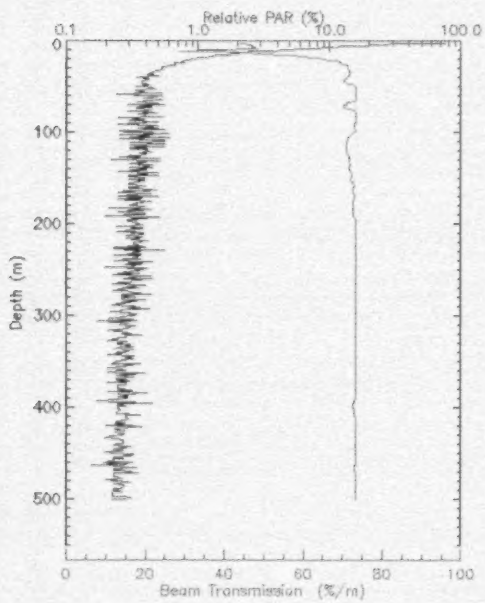




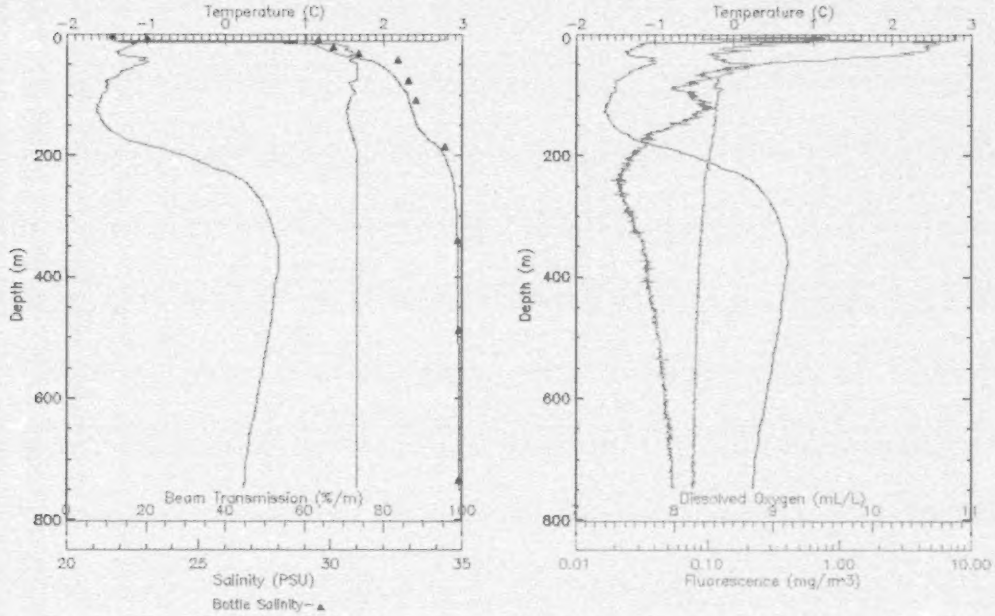
06/09/2013: Cast 72, Station A1-05 (Lower slope)



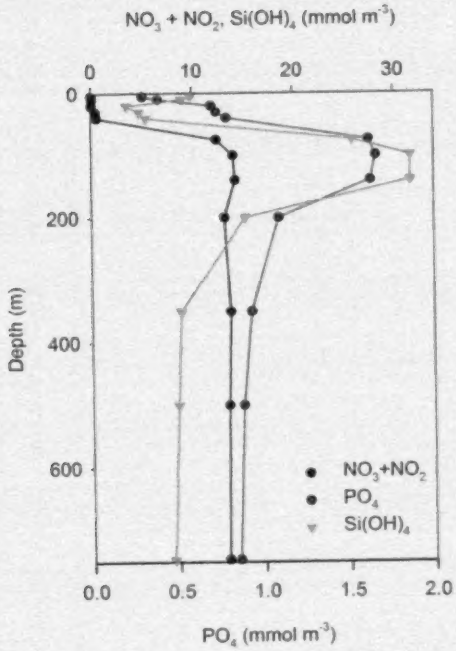


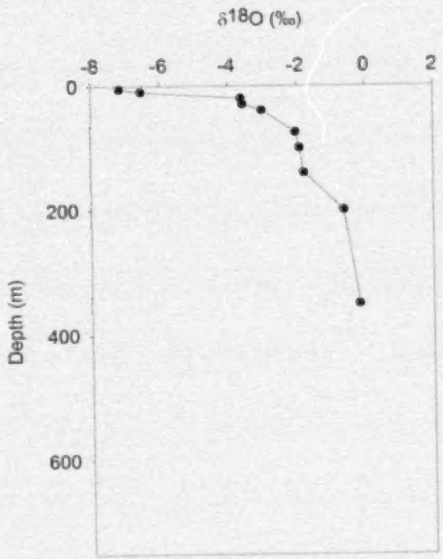


06/09/2013: Cast 73, Station A1-06 (Lower slope)

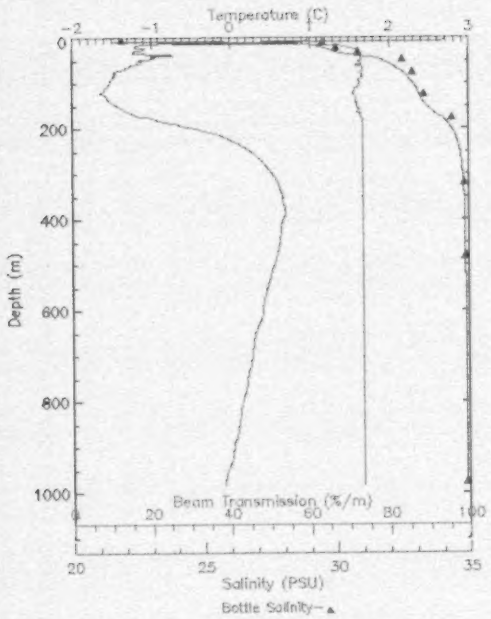


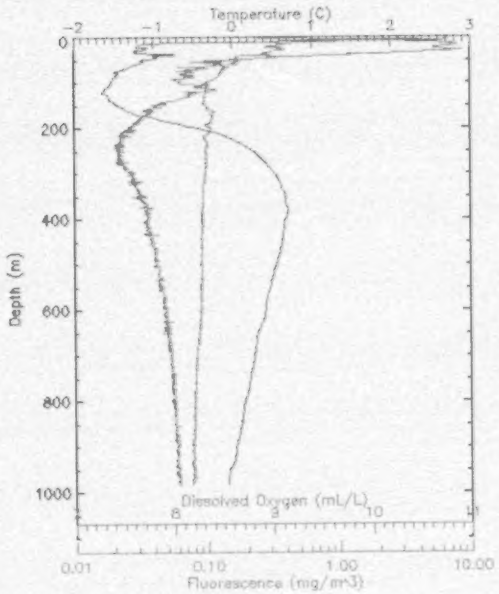
06/09/2013: Cast 73, Station A1-06 (Lower slope)

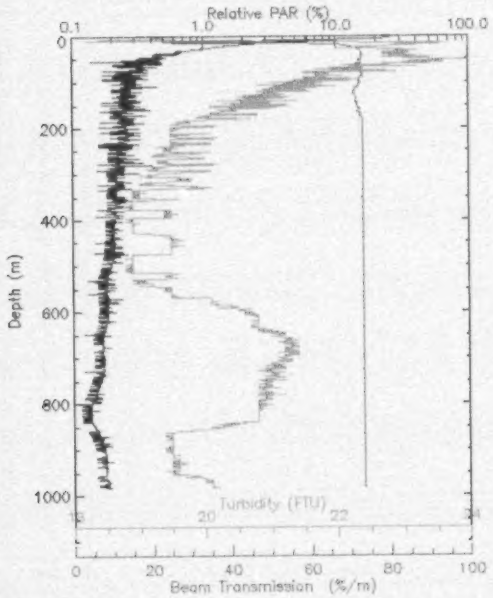




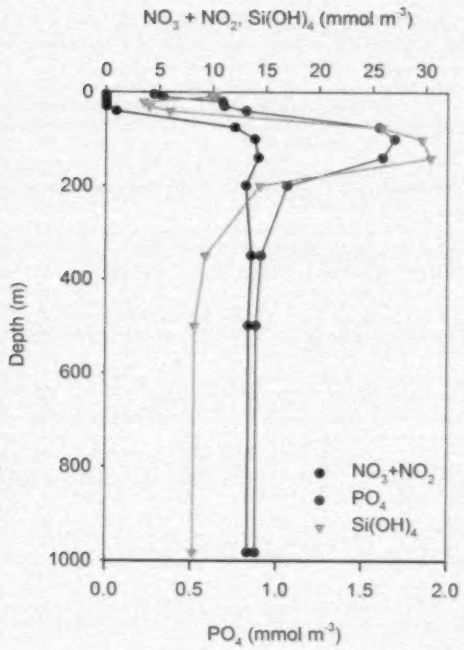
06/09/2013: Cast 74, Station A1-07 (Lower slope)

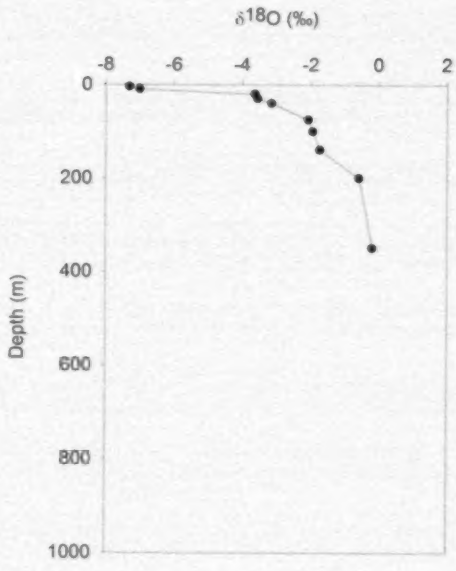




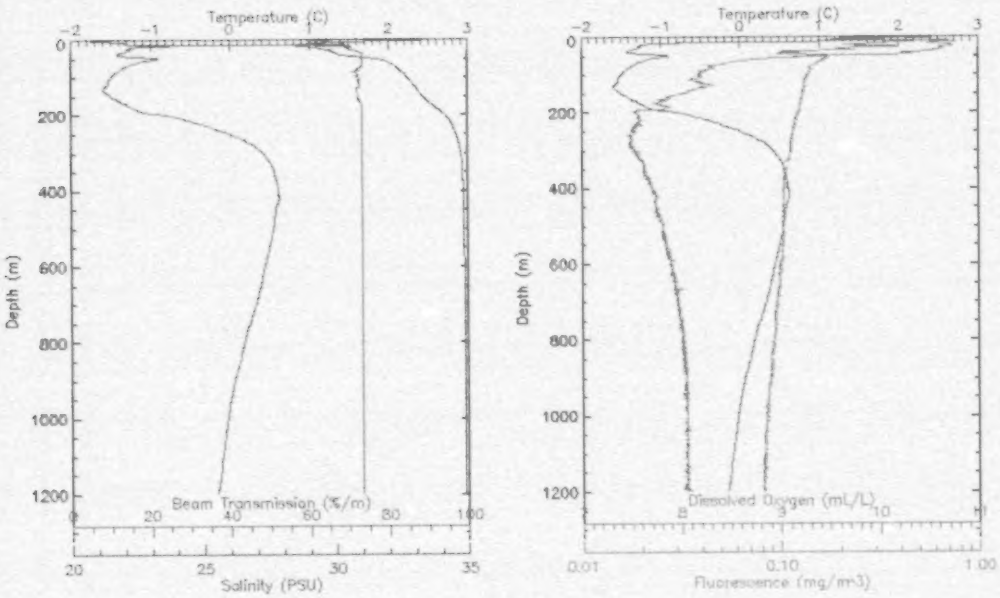


06/09/2013: Cast 74, Station A1-07 (Lower slope)

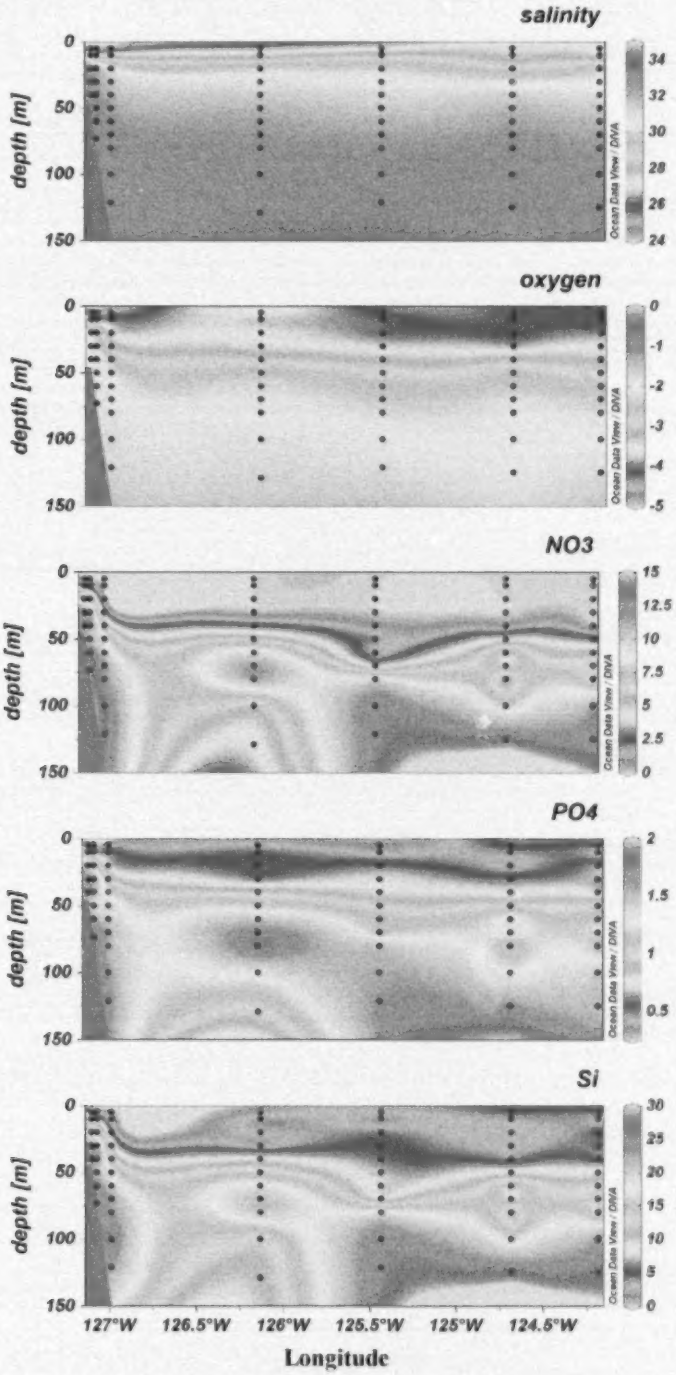




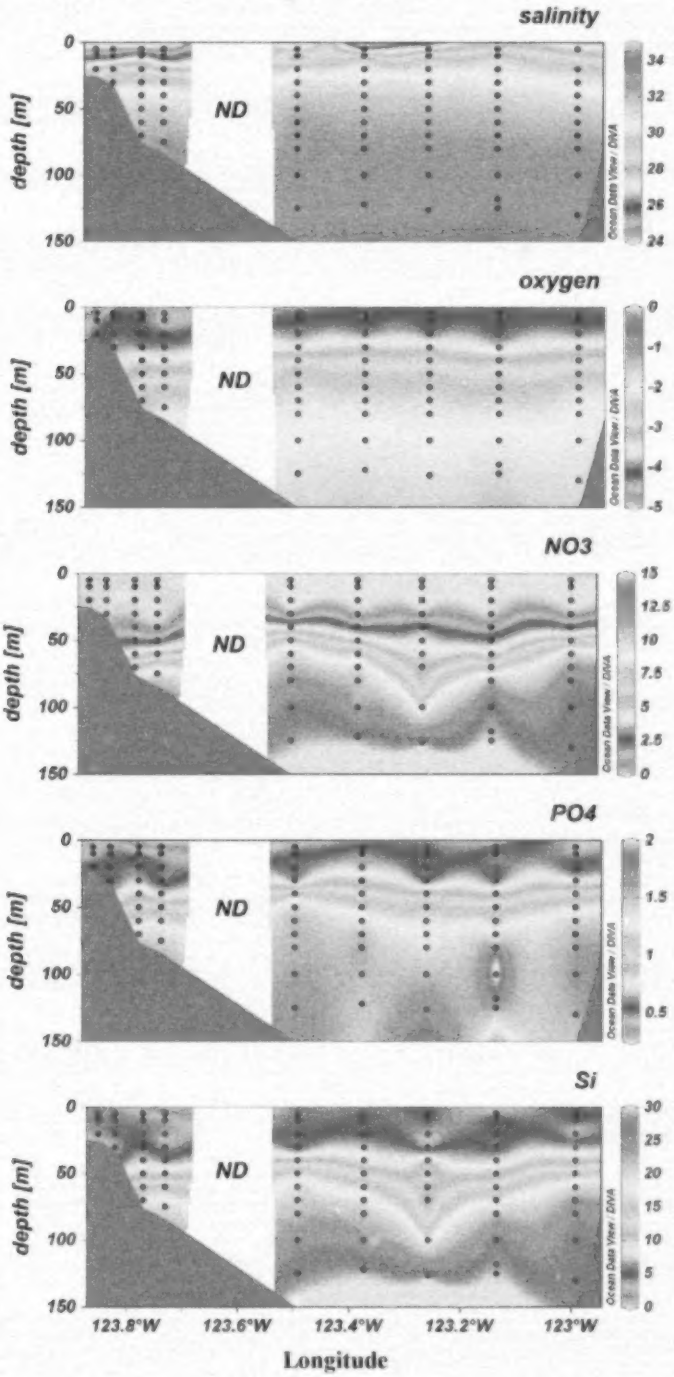
09/09/2013: Cast 76, Station DWT-01 (Lower slope)



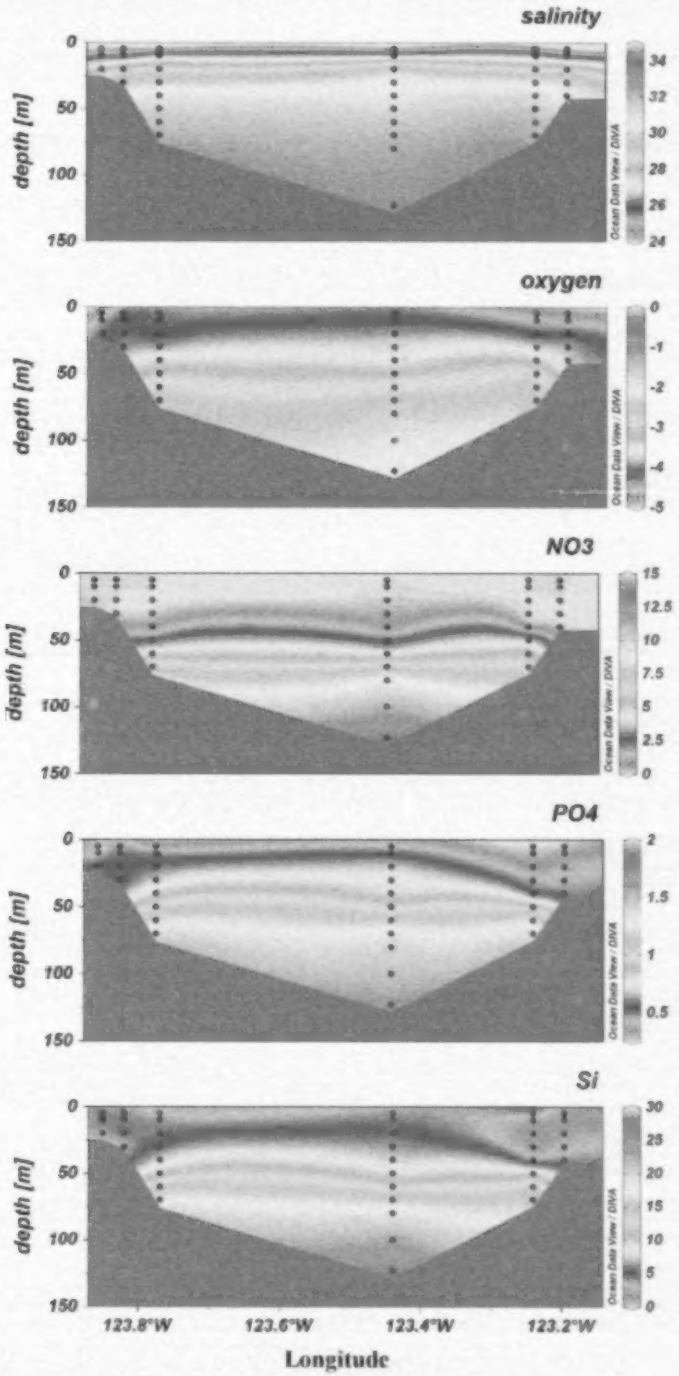
Appendix 4. Salinity (bottle values, PSU), $\delta^{18}O$ (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the CBH transect, August 2013.



Appendix 5. Salinity (bottle values, PSU), $\delta^{18}O$ (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the DAR transect, August 2013. Due to station proximity, BPT-01 and 02 are included in the section plot. No data (ND).



Appendix 6. Salinity (bottle values, PSU), $\delta^{18}O$ (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the BPT transect, August 2013. Due to station proximity, DAR-01 is also included in the section plot.



Appendix 7. Salinity (bottle values, PSU), $\delta^{18}O$ (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the ULU transect, August 2013.